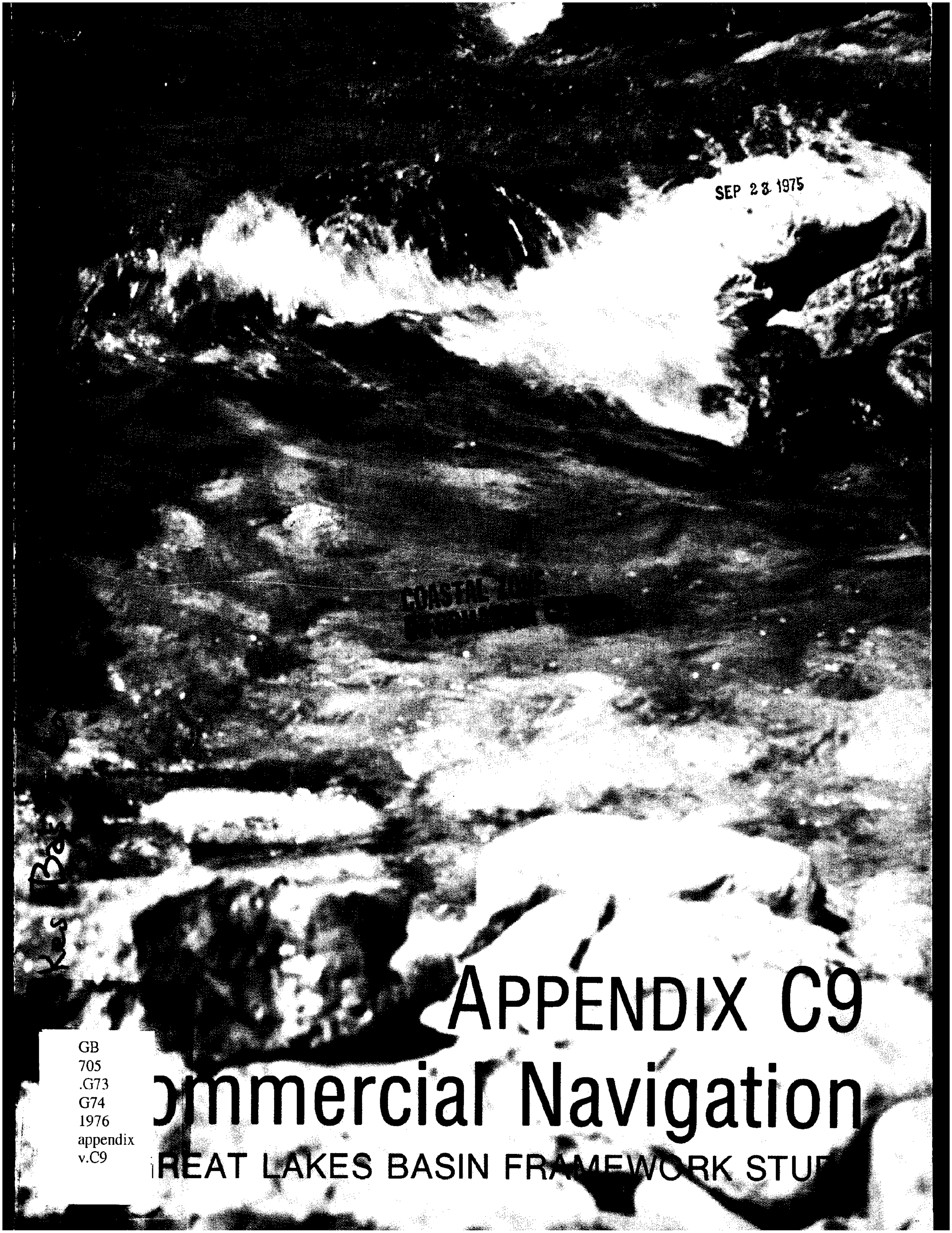

APPENDIX C9

ommercial Navigation

REAT LAKES BASIN FRAMEWORK STU

Great Lakes Basin Framework Study

APPENDIX C9

COMMERCIAL NAVIGATION

GREAT LAKES BASIN COMMISSION

Prepared by the Commercial Navigation Task Group of the Navigation Work Group

Sponsored by the U.S. Department of the Army, Corps of Engineers

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Cover photo by Kristine Moore Meves.

This appendix to the *Report* of the *Great Lakes Basin Framework Study* was prepared at field level under the auspices of the Great Lakes Basin Commission to provide data for use in the conduct of the Study and preparation of the *Report*. The conclusions and recommendations herein are those of the group preparing the appendix and not necessarily those of the Basin Commission. The recommendations of the Great Lakes Basin Commission are included in the *Report*.

OUTLINE

SYNOPSIS

The Great Lakes, connecting channels, and St. Lawrence River form a 2,342 mile waterway from the heart of the North American continent to the Atlantic Ocean. The availability of low-cost, waterborne transportation in conjunction with the rich natural resources of the area was a primary factor in the initial growth of the Great Lakes Basin and continued to provide a transportation base which is vital for its continued economic health. The Great Lakes service area contains 36 percent of the nation's population and accounts for 44 percent of the value added by manufacturing, 50 percent of all farm products sold, and 41 percent of employment. Since the first recorded navigation on the Great Lakes (a load of grain) in 1678, the system has grown to accommodate 237 million tons of traffic in 1970.

The abundance of iron ore and limestone near the upper Great Lakes and coal within 200 miles of the southern Lake ports constitutes an incomparable resource combination that, along with the growing consuming areas, has dictated the location of 40 percent of the nation's steelmaking capacity along the southern Lake Michigan and the western and southern Lake Erie shores. An additional 33 percent of steelmaking capacity which is not in the Basin (Pittsburgh, Pennsylvania, and Youngstown and Cincinnati, Ohio) is served by Lake Erie ports. The concentration of manufacturing in the Great Lakes Basin is indicated by the value added by manufacturing of $1,261 per capita in the seven major port areas. This is 60 percent more than the average for the entire country ($792).

Low, medium, and high estimates of prospective Great Lakes traffic (domestic and foreign) were developed for this study. The low projection of traffic might occur if the limited objective were pursued throughout the Basin. The medium projection could be the normal or national income, and the high projection the accelerated or regional development. Mixing these objectives may be more desirable than selecting one for the entire Basin. The interdependence and regional nature of bulk traffic must be recognized. The low and high estimates represent ultimate extremes which, although possible, are unlikely to occur. The medium projection is used in this study. Actual 1970 traffic and the medium projections for 1980, 2000, and 2020 are presented in tabular form in millions of short tons.

	1970	1980	2000	2020
Iron Ore	94.2	124	164	221
Coal	49.0	62	74	74
Limestone	36.1	46	70	104
Grain	21.7	26	32	39
Subtotal	201.0	258	340	438
Overseas General	8.2	10	13	16
Other	28.0	36	47	61
Total	237.2	304	401	515

Total annual U.S. and Canadian traffic on the Great Lakes is estimated to increase from 237 million tons in 1970 to 304, 401, and 515 million tons in 1980, 2000, and 2020. This commerce is estimated to generate 5.4, 7.2, and 9.2 billion dollars per year in direct and secondary income. The portion attributed to general cargo traffic is $500 million, $600 million, and $740 million annually in 1980, 2000, and 2020. These estimates assume that growth is not limited by channel and/or lock capacities. However, specific ongoing studies of St. Lawrence Seaway traffic and the Lake Erie-Lake Ontario Waterway study show that economic capacity of present lock facilities in the Welland Canal and in the Seaway will very likely be exceeded by 1990.

The cost of transporting bulk commodities on the Great Lakes in 1970, using 1971 vessel operating cost for both U.S. and Canadian vessels, is estimated at $386 million as follows: iron ore, $213 million; coal, $53 million; limestone, $40 million; and grain, $80 million.

Future waterfront planning should be comprehensive in nature. Commercial, industrial, social, recreational and aesthetic needs and values must be considered. Beautiful scenery, fishing, swimming, power boating, sailing and agriculture, mining, manufacturing, power supply and transportation all contribute to the quality of life, and all are dependent on the water resources of the Basin. Some uses are complementary, others are competitive. Prime consideration must be given to the effects of any proposed action on the environment and to restoring, preserving, and improving the Great Lakes for the benefit of all users.

FOREWORD

This appendix was prepared by the Commercial Navigation Work Group. Technical reports, statistics, and views of private interests and State and Federal agencies were the sources of information. Principal contributors were the U.S. Army Corps of Engineers, the Maritime Administration, the St. Lawrence Seaway Development Corporation, the Department of Transportation, the Lake Carriers' Association, the University of Toledo, and other navigation interests.

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INTRODUCTION

Purpose and Scope

The specific objective of this appendix is to determine the extent, nature and timing of a development program necessary to meet the requirements of future commercial navigation. For clarity and ease of presentation, recreational navigation is treated separately in Appendix R9, *Recreational Boating*.

This appendix presents information on the historical development, current status, and projected needs of the Great Lakes-St. Lawrence Seaway commercial navigation system. Estimates of Federal, State, and local program requirements are given for the planning periods 1980, 2000, and 2020. The scope of this appendix includes the entire commercial navigation system from Lake Superior through the St. Lawrence Seaway to the Atlantic Ocean. While concentrating on the U.S. portion of the Basin, it includes all waterborne commerce with origins or destinations in the Great Lakes Basin (Figure C9-1). Planning subareas are delineated by county boundaries that approximate groups of drainage basins (river basin groups) draining into the Great Lakes.

Study Procedure

Study procedure involved:

(1) assembling available information on the transportation systems serving the Great Lakes Region

(2) assembling information on existing private, local, public, and Federal programs for navigation and summarizing technology, problems, and possible solutions connected with the various transportation modes

(3) surveying the present status of harbors, connecting channels, and deepening projects up to present day conditions, and describing the status of authorized studies

(4) tabulating existing traffic, projecting low, medium, and high ranges of prospective traffic, and providing appropriate summary tables for existing and prospective traffic

(5) analyzing facilities associated with each of the major commodity movements and the relationship of water and land modes of transportation, which establishes the economics of the deep-draft system

(6) assessing the restrictions inherent in the Great Lakes system, including lock sizes, channel depths, length of season, land facilities, cargo handling aids, traffic control

(7) defining the system's opportunities and needs in river basin groups and local areas for planning periods 1970 to 1980, 1980 to 2000, and 2000 to 2020. Included are estimates of prospective traffic, alternative solutions, approximate costs, and development of a framework plan for commercial navigation to meet national, regional, and environmental objectives.

Organization

The available information concerning transportation systems serving the Great Lakes Basin is presented in Section 1. Complementary and competitive roles of alternative modes of transportation, problems facing the alternative modes and their possible solutions, and the relationship of the Great Lakes transportation system to seacoast areas are discussed.

The Great Lakes-St. Lawrence Seaway is described in Section 2. Information is presented on development of the Seaway, which has been a coordinated undertaking of the Federal governments of the United States and Canada.

Transportation studies of existing and prospective waterborne commerce are given in Section 3. Summary tables of trends in commodity movements are developed to determine the needs for improvements for the projection periods.

The existing vessel fleet and the opportunities for technological advancements are analyzed in Section 4. The size and composition of the future fleet are discussed in relation to the size of locks and channels.

A discussion of alternatives, costs, and navigation needs is presented in Section 5. A

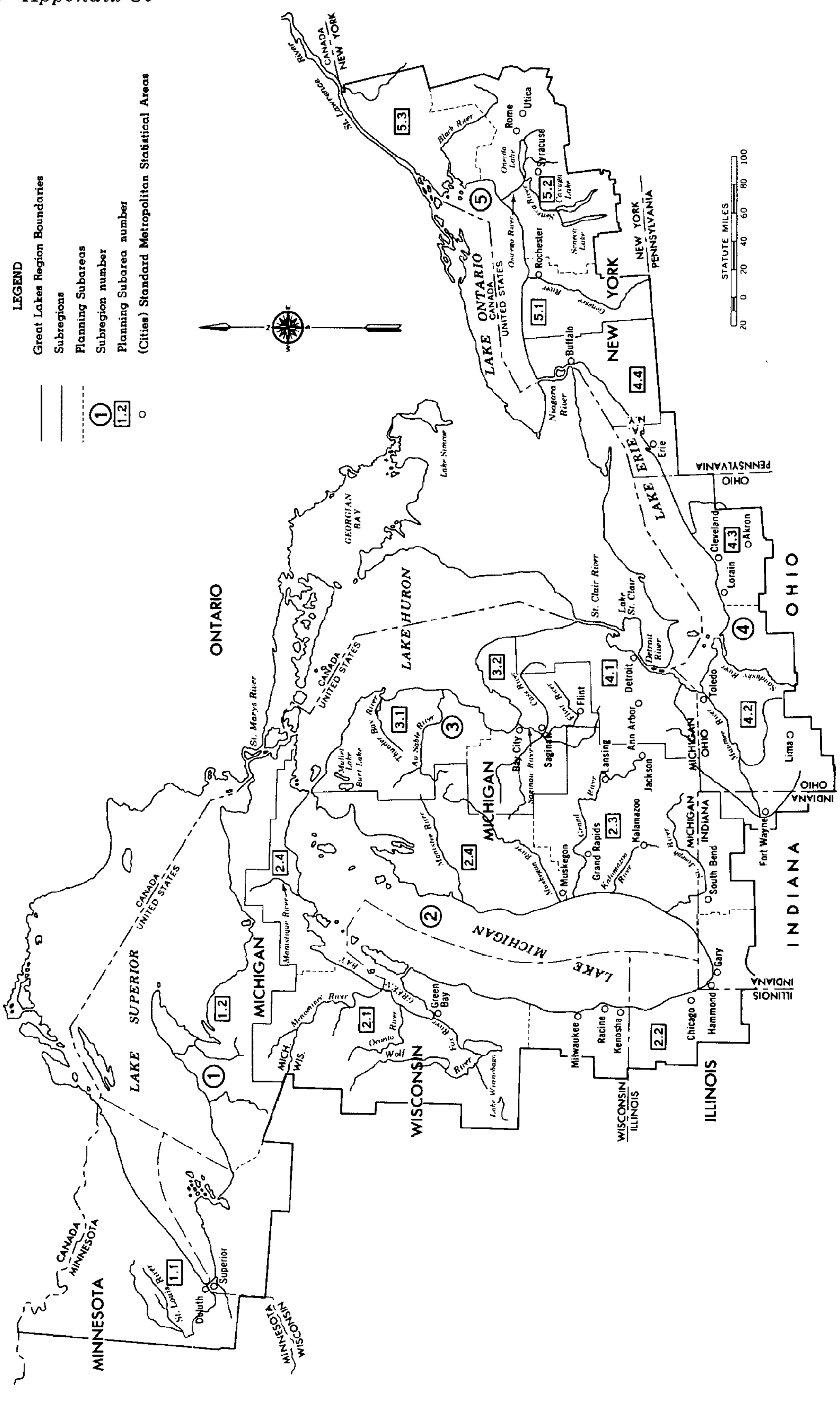


FIGURE C9–1 Great Lakes Region Planning Subareas

framework plan for action in the planning periods of 1980, 2000, and 2020 is developed.

Historical Development

The five Great Lakes and their connecting waterways and canals form a water highway 2,342 miles long from the heart of the North American continent to the sea via the St. Lawrence River. Of this, 1,270 miles are within the Great Lakes. The remainder is along the St. Lawrence River.

The first recorded commercial navigation on the Great Lakes commenced with the launching of a 10-ton sailing vessel at Fort Frontenac (the present site of Kingston, Ontario) in November, 1678.[26] Sieur de La Salle built this ship to transport supplies from Fort Frontenac through the Niagara River to a portage that led to an advanced base above the Falls. The first cargo was a load of grain obtained in trade from the Seneca Indians at their camp near the present site of the City of Toronto. The trip took nine days. During the winter of 1678–79 La Salle built a 40-ton sailing ship, the *Griffon*, which was launched in May of 1679. In August of that year he sailed this ship across Lake Erie, towed it up the Detroit and St. Clair Rivers, sailed the full length of Lake Huron to the Mackinac Straits and down Lake Michigan to Green Bay. Loading the ship with a rich cargo of furs obtained in trade, La Salle sent it back to his base on the Niagara River with orders to return with more supplies for further exploration. The ship was lost in a storm on Lake Huron. Because of these early voyages, La Salle has been called the father of navigation on the Great Lakes.

The opening of the Northwest Territory in 1787 (Illinois, Indiana, Michigan, Ohio, and Wisconsin) was a great stimulus to development of the Great Lakes area. As westward migration followed the water courses, navigation developed as a natural means of communication.

By the early 1800s some two dozen lakeshore communities had been established along Lakes Ontario and Erie, at Prescott and Ogdensburg on the St. Lawrence River, and at Detroit on the Detroit River. The midwest farmlands were fertile and the climate was favorable for growing grain, which became one of the first sources of income for farmers.

Trade in furs was also an important item of commerce of the area. In 1797 the Northwest Fur Company built a small lock on what is now the Canadian side of the St. Marys River at Sault Sainte Marie. This lock, having a lift of less than half the total drop (19 feet) in water level, was for canoes and *bateaux*.[27]

Because highways and railways were not developed, water transport provided the only means of getting products to the eastern markets. The completion of the Erie Canal in 1825 provided the initial water route from the Illinois prairies to the Atlantic coast. The canal's 4-foot depth and 40-foot width accommodated boats with capacities up to 30 tons. Grain, for example, was loaded on lake boats at Lake Michigan ports, carried to Buffalo, and then transferred to canal boats on the Erie Canal and delivered directly to New York, a total distance of 1,400 miles. Chicago was the major grain shipping port until the 1880s. Grain was brought to Chicago on wagon trains up to 80 wagons long, traveling on plank roads built out into the prairies. The rapid growth of waterborne commerce between the midwest and the Atlantic seaboard is presented in tabular form.[26]

Year	Total Tons
	(All freight including grain)
1836	54,000
1846	507,000
1856	1,210,000
1867	2,130,000

One of the many difficulties obstructing development of Great Lakes navigation into a single system was the 602-foot difference in elevation between tidewater and Lake Superior. Most of this, 591 feet, occurs in three areas. The rise in the St. Lawrence River from tidewater to Lake Ontario is 246 feet. The second is a 326-foot lift over the Niagara escarpment into Lake Erie, and the third is a 19-foot lift on the St. Marys River at the outlet of Lake Superior. For many years goods were unloaded from ships at each of these barriers, transported overland, and reloaded on other ships in the Lake beyond.

In 1680, Dollier de Casson, Superior of the Sulpician Order in Montreal, originated the concept of making a canal through the St. Lawrence River. In the early 1700s work actually began on a canal to provide a 3-foot deep channel between Lake St. Louis and the St. Pierre River. Although never completed it was followed by other small canals. By 1780 a series of small locks, 40 feet long, six feet wide, and 2½ feet deep were in operation between Lake St. Louis and Lake St. Francis. The Lachine Canal was completed in 1825 and by

1850 a channel with maximum depth of nine feet was available from the Atlantic Ocean to Lake Ontario. The first Welland Canal across the Niagara peninsula was opened in 1829 and the improvements and modifications that formed the second Welland Canal were completed by 1844.[26]

A major change in transportation service on the Great Lakes occurred during the mid-19th century when the demand for steel exceeded the capacity of eastern iron ore reserves. Consequently the mines of Michigan and Minnesota became competitive. The first mine (on the Marquette Range) was opened in 1854.

A canal to by-pass St. Marys Falls at Sault Sainte Marie and the State of Michigan Lock, the first ship lock at Sault Sainte Marie, was completed in 1855, providing a 9-foot navigable channel from the Atlantic Ocean to Lake Superior. This facilitated economic delivery of ore to Pittsburgh furnaces. Larger vessels, terminal facilities, and complementary inland rail facilities were constructed. The rail cars and ore vessels, which normally would be empty on the back haul, were used to carry coal at out-of-pocket rates (usually half the cost of ore movements downbound) to energy-deficient upper lake ports and cities.

Settlers came with their families to mine the ore and to work in the growing centers of commerce and industry (Chicago, Milwaukee, Detroit, Cleveland, Buffalo, and Toronto).

While construction of the 9-foot canal system stimulated navigation on the Great Lakes, the rapid development of the railways during the 1840s and 1850s provided stiff competition. A rail connection between Rochester on Lake Ontario and Albany on the Hudson River was completed in 1841 and a connection between Toledo on Lake Erie and the Ohio River was finished in 1848. Chicago was connected to the east by rail in 1852, and in 1854 a line extended from Chicago to the Mississippi River. A railway from Montreal to Toronto was completed in 1856.

The effectiveness of the rail competition is reflected by the following statistics: between 1868 and 1898 total grain shipments (ship and rail) from Chicago increased from 41,000,000 bushels to 254,000,000 bushels, while the rail portion of these shipments increased from 3,000,000 bushels in 1868 to 102,000,000 bushels in 1898.[27]

The construction of the Canadian Pacific Railroad encouraged the growing of grain and its shipment from the Canadian ports of Fort William and Port Arthur (now known as Thunder Bay) beginning in 1884. More than 88,000,000 bushels were shipped from Lake Superior ports in 1898.

However shipments of iron ore and coal on the Lakes soon eclipsed the grain movement. The first shipments of ore from the Mesabi Range began in 1892. By 1910 approximately 42,000,000 tons were shipped annually. Coal shipments totalled 26,000,000 tons and grain shipments equalled 6,000,000 tons (approximately 240,000,000 bushels) in 1910. These three items accounted for more than 95 percent of the total traffic on the Great Lakes at that time.

In the late 1800s the government of Canada undertook a new canal building program, which, on its completion in 1905, provided a minimum draft of 14 feet from the Atlantic Ocean to Lake Superior. This established much of the present traffic pattern. The use of lake freighters, which were developed solely for the movement of bulk cargoes on the Great Lakes, resulted in savings that made the Lake system again competitive with railroads.[26] This marked the end of rail dominance in transporting bulk cargoes.

While the canals of the Great Lakes were being developed, radical changes were also being made in the vessels. Prior to enlargement of the Welland Canal in 1844, there were some 224 vessels, with an aggregate tonnage of 23,868 tons, navigating the upper Lakes. Of this number, 114 ships with a registered tonnage of 16,200 tons were relegated to the Lakes above the Welland Canal. The development of propeller-driven ships was a major breakthrough in the expansion of economical water transportation. Within the 42 years following the launching of the first propeller-driven ships in 1841, the side-wheelers were totally supplanted and sailing ships either disappeared or became barges towed by the new propeller ships. By 1883 more than 1,500 vessels of all descriptions carried commercial cargoes valued between $50 and $60 million on the Great Lakes. Of these almost 600 of the largest ships could not traverse the Welland Canal due to the minimum draft available (nine feet).[26]

Since 1904 there have been a number of major changes in the navigation system in the Great Lakes which have increased the capability of the system. Among the most important was the construction of the new Welland Ship Canal completed in 1932. The seven locks were 860 feet long, 80 feet wide, and 30 feet deep over the sills. Locks of these dimensions could accommodate the lake freighters of that time. However, it was not until metallurgical developments made during and after World War II provided steels of a greater strength and quality that lake ships having the maximum permissible dimensions for use in the Welland Canal were constructed. It was not until after the opening of the St. Lawrence section of the Seaway in 1959 that ships 730 feet long, 75 feet wide, and drawing 25 feet of water began to appear. These ships, capable of carrying cargoes of 25,000 to 28,000 tons, were faster and more economical than their earlier kindred on the Lakes. One of these ships could carry enough cargo to fill eight or nine of the "canallers" which were then in use through the St. Lawrence River canals, or all the grain carried by 600 standard railroad box cars. In a single trip one new ship could carry all of the wheat produced on 30 sections of prairie farm land. However, all of these larger ships were limited to the Great Lakes. They were unable to use any of the smaller canals below Prescott until the St. Lawrence section of the Seaway was opened in 1959. The locks along the St. Lawrence were similar in size to those on the Welland and Sault Sainte Marie Canals. In 1968, the opening of the new 1,200-foot long Poe Lock at Sault Sainte Marie, which can handle ships up to 1,000 feet long, further stimulated the growth in vessel size and economy.

In 1887 the average size vessel passing through the canal at Sault Sainte Marie was 600 tons, and the total cargo moved was 5,000,000 tons. By 1924 vessel size had increased to 3,000 tons and total cargo movements were nearly 50,000,000 tons.[26] In 1970 total cargo movements were more than 200,000,000 tons and average vessel cargo per passage was 7,400 tons. In the 1972 season a 1,000-foot long self-unloading carrier, capable of carrying up to 58,000 tons of iron ore and loading and unloading as much as 20,000 tons per hour, began operating on the Lakes.

Navigation Regulations and Policies

The Constitution of the United States provides Congress with the power to regulate commerce with foreign nations, among the States, and with Indian tribes. An early Supreme Court decision held that commerce necessarily included power over navigation. To effectuate this power, Congress delegated power to several Federal agencies.

A detailed description of laws pertaining to navigation is contained in Appendix F20, *Federal Laws, Policies, and Institutional Arrangements*.

Section 1

RELATIONSHIPS OF ECONOMIC DEVELOPMENT AND TRANSPORTATION NEEDS

1.1 General

The historical relationship of freight traffic to the major economic indicators of gross national product and population can be seen in Table C9-1. Unless otherwise indicated, tons are short tons (2,000 lbs.) and miles are statute miles (5,280 ft.). The total volume in ton-miles of domestic intercity freight traffic increased 2.7 times or at an annual rate of 3¾ percent per year from 1940 to 1967. The annual rate of change was 5⅜ percent from 1940 to 1950, two percent from 1950 to 1960, and 4⅛ percent from 1960 to 1969. The rates of change for the periods 1940 to 1950 and 1960 to 1969 are approximately comparable to the annual rate of change in gross national product. In the period 1950 to 1960 the rate of change of two percent was slightly more than the annual rate of change in population which was 1¾ percent. Per capita freight traffic volume has followed the upward and downward inflections of per capita GNP and the annual rates of change have been of the same order of magnitude.

The shifts in the national distribution of freight traffic between transport modes because of intermodal competition since 1940 is

TABLE C9–1 Relationship of Domestic Intercity Freight Traffic, GNP, Population, Per Capita Freight Traffic Volume, and Per Capita GNP, 1940 to 1969

Year	Domestic Intercity Freight Traffic Volume (million ton miles)	Gross National Product (58$)[a]	Population (millions)	Per Capita Freight Traffic Volume (ton miles)	Per Capita GNP (58$)
1940	651,204	227.2	132.1	4,930	1,720
1950	1,094,160	355.3	152.3	7,184	2,333
1960	1,329,995	487.7	180.7	7,360	2,699
1969	1,898,200	727.1	202.6	9,369	3,589
		Indexes of Change			
1940-67	270	296	151	180	196
1940-50	168	156	115	146	136
1950-60	122	137	119	102	116
1960-69	143	149	112	127	133
		Compound Rates of Change			
1940-67	3-3/4%	4-1/8%	1-9/16%	2-3/16%	2-9/16%
1940-50	5-3/8%	4-1/2%	1-7/16%	3-7/8%	3-1/8%
1950-60	2%	3-1/4%	1-3/4%	23/96%	1-1/2%
1960-69	4-1/8%	4-5/8%	1-1/4%	2-3/4%	3-1/4%

SOURCE: Table 2 and Economic Report of the President Together With the Annual Report of the Council of Economic Advisors, transmitted to the Congress January 1969, U.S. Government Printing Office, Washington, D.C., 1969. (Also 1971 edition).

[a]Units are billions of 1958 dollars.

shown in Table C9–2. In 1940 motor vehicles and pipelines together transported only 30 percent as many ton-miles as the railroads. In 1969 they accounted for five percent more ton-miles than railroads. The volume of air freight traffic increased 228 times from 1940 to 1969. During the nine years 1960 to 1969 the rate of increase tapered off to 4.1 times. During the period 1940 to 1969 the share of total traffic volume by railroads decreased from 63 percent to 41 percent and the share of inland waterways declined from 18 percent to 16 percent. At the same time increases are indicated in the percentage shares of motor vehicles from 10 percent to 22 percent, oil pipelines from 9 percent to 22 percent and airways from .002 percent to .169 percent. Table C9–3 compares the distribution of ton-mileage and revenue for regulated freight carriers. Revenue per ton-mile ranged from $0.0015 for waterways to $0.156 for airways. In other words, the ratio of revenue per ton-mile, assuming waterways to be one, would be pipelines 2.5, railroads 10.4, motor trucks 22.4, and airways 104. In 1970 a study by the AWO (American Waterways Operators) estimated that a shipper's dollar will move a ton of freight 333 miles by barge, 67 by rail, 15 miles by truck and five miles by air.

1.2 Economic Development and Area Resources

1.2.1 Location Astride Transportation Crossroads

From the viewpoint of economic development, the dominant characteristics of the Great Lakes Basin is its location within the highly industrialized and well-populated north central United States. It stands astride the transcontinental link between the agricultural regions of the north central States and the high consumption areas to the east. Included in the area are the major routes through the United States manufacturing belt and the direct line between the metropolitan complexes of Chicago and New York.

The 95,000 square miles of water surface, which makes the Great Lakes the world's largest body of fresh water, is capable of transporting more than 100 billion ton-miles of waterborne freight per year.

1.2.2 Great Lakes Tributary Areas

The region considered of interest to Great

TABLE C9–2 Volume of Domestic Intercity Freight Traffic by Type of Transport, 1940 to 1969[a]

Year	Total Traffic Volume	Railroads[b] Volume	Railroads[b] Percent of Total	Motor Vehicles Volume	Motor Vehicles Percent of Total	Inland Waterways[c] Volume	Inland Waterways[c] Percent of Total	Oil Pipelines Volume	Oil Pipelines Percent of Total	Airways[d] Volume	Airways[d] Percent of Total
1940	651,204	411,813	63.24	62,043	9.53	118,057	18.13	59,277	9.10	14	0.002
1945	1,072,490	736,184	68.64	66,948	6.24	142,737	13.31	126,530	11.80	91	0.008
1950	1,094,160	628,463	57.44	172,860	15.80	163,344	14.93	129,175	11.81	318	0.029
1955	1,298,060	654,573	50.43	223,254	17.20	216,508	16.68	203,244	15.66	481	0.037
1960	1,329,995	594,855	44.73	285,483	21.46	220,253	16.56	228,626	17.19	778	0.058
1965	1,650,997	721,055	43.67	359,218	21.76	262,421	15.89	306,393	18.56	1,910	0.116
1969	1,898,200	780,000	41.09	404,000	21.28	300,000	15.80	411,000	21.65	3,200	0.169

[a] In millions of ton-miles, except percent. Airways, prior to 1959 and other types of transportation, prior to 1960, exclude Alaska and Hawaii, except as noted. A ton-mile is the movement of one ton (2,000 pounds) of freight for the distance of one mile. Comprises public and private traffic, both revenue and nonrevenue. See also Historical Statistics, Colonial Times to 1957, series Q 1-11.
[b] Includes electric railways, express, and mail.
[c] Includes Great Lakes. Includes Alaska for all years and Hawaii beginning 1959.
[d] Domestic revenue service only. Includes express, mail, and excess baggage.

Source: Interstate Commerce Commission; Annual Report, Statement No. 6103, Intercity Ton-Miles, 1939-1959, April 1961 and Transport Economics, December 1967. Statistical abstract of U. S. 1971.

TABLE C9–3 Comparison of Ton Mileage and Revenue by Type of Transport

	1940		1960		1969				
Transport Type	% of Ton Miles	% of Revenue	% of Ton Miles	% of Revenue	Ton Miles (Billions)	Total % Ton Miles	Revenue (Billions)	Total % Revenue	Revenue per Ton Mile
Railroad	61.3	75.4	44.1	49.4	780	41.1	$ 12.2	44.0	$0.0156
Water	19.1	1.8	16.8	2.0	300	15.8	0.45	1.6	0.0015
Oil Pipeline	9.6	4.6	17.4	4.5	411	21.6	1.1	4.0	0.0038
Airways							6.4		
Passenger							(5.7)		
Freight	0.002	0.46	0.059	1.6	3.2	0.169	(0.5)	1.8	0.156
Motor Vehicles	10.0	17.7	21.7	42.5	404	21.3	13.5	48.6	0.0334
Total	100%	100%	100%	100%		100%		100%	0.0146
Ton Miles[a]	619		1,314		1,892.2				
Revenue[a]		4.89		16.99			27.75		

[a]billions

SOURCE: Transportation of Freight in the Year 2000, by Sir James Easton (Consultant to Detroit Edison Co.) 1971, pp 88-89, Reference No. 8. Statistical Abstract of the United States, 1971, Reference No. 52.

NOTE: The breakdown of the approximate 16% of intercity ton miles on inland waterways between the St. Lawrence Seaway/Great Lakes and other inland waterways has averaged about 6.8% for the former and 9.2% for the latter over the last ten years.

Railroads loss of their percentage share of ton mileage shows a definite slowing up of the decline. From 1942 to 1960 their share fell by nearly 25-1/2% or an average of 1.4% a year. From 1960 to 1968 the total percentage drop was only 2.80% or only 0.35% per year.

Most of the net gain since 1960 has been by pipelines which have increased their share of ton mileage by about 4%. In terms of growth rate, air freight ton mileage has shown the most spectacular increase by approximately doubling its share every four years. As a percentage of the national total for all modes the air freight share is still small.

Lakes harbors for various types of overseas cargo includes the eight Great Lakes States and 11 additional contiguous States (See footnote b, Table C9–4). This 19-State area generates approximately 25 percent of the nation's general cargo export traffic. Although one-half of this traffic has a transportation cost advantage via the Great Lakes-St. Lawrence Seaway system as compared to alternative routes, only four million tons, or a little more than five percent, of the nation's overseas general cargo exports are being transported via the Great Lakes-St. Lawrence Seaway navigation system. The areas contributing overseas shipments of U.S. grain produce 79 percent of U.S. grain and the six midwest States bordering the Great Lakes, Minnesota, Wisconsin, Illinois, Indiana, Michigan, and Ohio, produce 37 percent of U.S. grain. The Great Lakes percentage share of the U.S. grain exports, which was 14 percent in 1964 and 17.8 percent in 1971, is projected to increase to 20 percent in 1980. Pertinent statistics on the 19-State area and the eight Great Lakes States are presented in Tables C9–4, C9–5 and C9–6.

1.3 Major Port Areas

1.3.1 Duluth-Superior (Planning Subarea 1.1)

The nearly 43 million tons of freight traffic in 1970 make this one of the most important harbors on the Great Lakes and in the nation. The harbor is served by seven railroads. Principal commodities are grain and iron ore (pellets). There is potential for shipment of substantial tonnage of low sulphur western coal.

1.3.2 Port of Chicago (Planning Subarea 2.2)

The Port of Chicago combines lake, ocean, and river shipping and serves as a link between the Mississippi River system and the Great Lakes-St. Lawrence Seaway system. The port handled 48 million tons of cargo in 1970, including 35 percent of all U.S. overseas cargo entering or leaving the Great Lakes. The city originates 30 percent of the nation's air cargo and is served by 28 scheduled commercial airlines. O'Hare Field is the world's largest and busiest airport, with 27.5 million passengers annually. It has handled more than 2,000 aircraft movements per day. One out of every five foreign visitors passes through customs at O'Hare Field. The Chicago-Northwestern Indiana SMSA had a 1970 population of 7.6 million.

1.3.3 Port of Detroit (Planning Subarea 4.1)

Detroit is served by nine railroads, 200 truck lines, 15 airlines, five freight carriers, and 50 ship lines. Rail freight tonnage totaled 30.3 million in 1968. The Port of Detroit cargo tonnage was 31 million in 1970, 2.5 million tons of

TABLE C9-4 Land Area, Population, and Economic Activity in the Great Lakes Area Compared to U.S. Totals

Item	United States[a]	Great Lakes—Hinterland[b] Number or Amount	Percent of U. S.	Great Lakes—Border States[b] Number or Amount	Percent of U. S.	Upper Great Lakes[c] Number or Amount	Percent of U. S.
	(Number and Percent of the U. S.)						
Land area, sq.mi., 1970[d]	2,963,998	1,205,286	40.7	366,569	12.4	115,352	3.9
Population, 1970[d]	202,112,686	73,144,566	36.2	52,428,512	25.9	2,876,345	1.4
Manufacturing - 1967[e]	($1,000,000)						
Value Added	261,983.8	114,209.5	43.6	93,804.6	35.8	2,262.2	1.0
Capital Expenditures	21,503.0	9,111.6	42.4	7,508.9	34.9	215.1	1.0
	(1,000 Employees)						
Employment	19,323.2	7,858.2	40.7	6,473.2	33.5	184.3	1.0
Agriculture - 1969[f]	(Value in $1,000)						
All farm products sold	Not Available	22,766,029	-	10,034,927	-	1,102,461	-
All crops sold	" "	7,089,188	-	3,596,953	-	253,136	-
Livestock sold	" "	11,725,262	-	3,451,596	-	241,904	-
Poultry and poultry products sold	" "	752,392	-	515,030	-	76,005	-
Dairy products sold	" "	2,802,193	-	2,222,484	-	489,954	-
	(Value in $1,000)						
Retail Sales - 1967[g]	310,214,393	114,629,621	36.9	83,082,764	26.8	4,138,341	1.3
Merchant Wholesalers' Sales - 1967[h]	459,475,967	167,699,282	36.5	123,731,255	26.9	3,045,205	0.7
Value of Mineral Production - 1969[i]	26,927,827	7,050,045	26.2	3,223,023	12.0	924,385	3.4

[a]Excludes Alaska and Hawaii.

[b]The Great Lakes--Hinterland includes the eight Great Lakes border States of Minnesota, Wisconsin, Michigan, Illinois, Indiana, Ohio, and western portions of Pennsylvania and New York, and also the eleven additional adjacent States of Montana, Wyoming, Colorado, North Dakota, South Dakota, Nebraska, Kansas, Iowa, Missouri, Kentucky, and West Virginia.

[c]The Upper Great Lakes area includes portions of the States of Michigan, Minnesota, and Wisconsin.

[d]U.S. Bureau of the Census, Census of Population: 1970, Number of Inhabitants, Selected State Reports, Final Report PC(1), U.S. Government Printing Office, Washington, D.C., 1971.

[e]U.S. Bureau of the Census, Census of Manufactures: 1967, General Summary Subject Report and Selected Area Reports MC67, U.S. Government Printing Office, Washington, D.C., 1970.

[f]U.S. Bureau of the Census, Census of Agriculture: 1969, Advance Individual Counties, U.S. Bureau of Census, 1971.

[g]U.S. Bureau of the Census, Census of Business: 1967, Retail Trade - Area Statistics, Volume II; U.S. Government Printing Office, Washington, D.C., 1970.

[h]U.S. Bureau of the Census, Census of Business: 1967, Wholesale Trade - Area Statistics, Volume III; U.S. Government Printing Office, Washington, D.C., 1971.

[i]U.S. Department of the Interior, Bureau of Mines: 1969, Minerals Yearbook, Volume III, Area Reports: Domestic; U.S. Government Printing Office, Washington, D.C., 1971.

which was overseas traffic. In addition more than 7,500,000 vehicle crossings are made each year over the border between Detroit, USA, and Windsor, Canada. Detroit Metropolitan Airport, with 5.8 million passengers annually, ranks 14th in the International Civil Aviation Organization list of the busiest world airport. The SMSA 1970 population was 4.2 million.

1.3.4 Toledo (Planning Subarea 4.2)

Toledo, the nation's third largest rail center, is served by nine railroads with a track mileage in Toledo of 1,200 miles. Strategically located at Lake Erie's western tip, Toledo's port ranks third on the Great Lakes and ninth in the United States. It handled 32 million tons of traffic in 1970, including one million tons of overseas traffic. To handle cargoes from Toledo, nine railroads, four major airlines, two extensive petroleum pipeline systems, and approximately 180 common carriers are available. Toledo's port is also the site of a foreign trade zone. The population of the SMSA in 1970 was 0.7 million.

TABLE C9–5 Wage and Salary Disbursements for Transportation in the Great Lakes Area

	Total	Railroad Transportation	Highway Freight & Warehousing	Other Transportation
	(millions of dollars)			
Total U. S.	22,956	5,945	8,685	8,326
8-State-G. L. Area	9,145	2,489	3,558	3,098
6-G. L. Border States	5,024	1,622	2,375	1,027
Michigan	730	193	412	125
Ohio	1,187	388	630	169
Indiana	535	205	270	60
Illinois	1,714	555	708	451
Wisconsin	376	104	198	74
Minnesota	481	177	157	147
2-States on both G. L. & North Atlantic	4,121	867	1,183	2,071
New York	2,842	380	632	1,830
Pennsylvania	1,279	487	551	241
	(Percent)			
Total U. S.	100.0	100.0	100.0	100.0
8-State G. L. Area	39.8	41.9	41.0	37.2
6-G. L. Border States	21.9	27.3	27.3	12.3
Michigan	3.2	3.2	4.7	1.5
Ohio	5.2	6.5	7.2	2.0
Indiana	2.3	3.4	3.1	0.7
Illinois	7.5	9.3	8.2	5.4
Wisconsin	1.6	1.7	2.3	0.9
Minnesota	2.1	3.0	1.8	1.8
2-States on both G. L. & North Atlantic	18.0	14.6	13.6	24.9
New York	12.4	6.4	7.3	22.0
Pennsylvania	5.6	8.2	6.3	2.9

Source: U. S. Department of Commerce, Office of Business Economics, "Survey of Current Business," August 1970.

TABLE C9-6 States of Great Lakes Region Share of U.S. Population, Area, Highway Mileage, and Railroad Mileage

	1960		1967 Mileage	
	Population[a] (1,000)	Area[b] (sq. miles)	Highway[c] (miles)	Railroad[d] (miles)
United States Total	179,992	3,615,123	3,704,914	209,292
States of Great Lakes Region Total	67,891	427,260	884,933	59,981
Illinois	10,084	56,400	128,479	10,928
Indiana	4,673	36,291	90,878	6,488
Michigan	7,833	58,216	113,895	6,372
Minnesota	3,422	84,068	126,879	7,990
New York	16,855	49,576	102,292	5,689
Ohio	9,737	41,222	108,049	8,031
Pennsylvania	11,328	45,333	113,166	8,477
Wisconsin	3,959	56,154	101,295	6,006
	Percent			
United States Total	100.0	100.0	100.0	100.0
States of Great Lakes Region Total[e]	37.7	11.8	23.9	28.7
Illinois	5.6	1.6	3.5	5.2
Indiana	2.6	1.0	2.4	3.1
Michigan	4.4	1.6	3.1	3.0
Minnesota	1.9	2.3	3.4	3.8
New York	9.4	1.4	2.8	2.7
Ohio	5.4	1.1	2.9	3.8
Pennsylvania	6.3	1.2	3.0	4.0
Wisconsin	2.2	1.6	2.7	2.9

SOURCE: U.S. Bureau of the Census, Statistical Abstract of the United States, 1969 (90th edition), Washington, D.C., 1969, pages 12, 163, 542, and 561.

[a] Estimates as of July 1. Includes Armed Forces stationed in area.

[b] Includes land area and water surface area.

[c] Includes all rural and municipal mileage under State, local, and Federal control.

[d] Actual length of line owned by line-haul companies in each State without duplication.

[e] Columns may not add up to total due to rounding.

1.3.5 Cleveland (Planning Subarea 4.3)

Cleveland is the largest city on Lake Erie and the third largest city on the Great Lakes. Cleveland's port handled 23 million tons of freight traffic in 1970. Four major railroads serve the Cleveland area. Cleveland Hopkins Airport with 4.4 million passengers annually ranks 24th in a list of the world's busiest airports. The 1970 SMSA population was 2.1 million.

1.3.6 Buffalo (Planning Subarea 4.4)

This is one of the largest railroad centers in the U.S., with 15 freight terminals scheduling 25,000 trains annually. It is serviced by seven major railroads representing one-third of the total railroad mileage in the U.S. and Canada. Approximately 150 motor carriers serve industries in the Buffalo Metropolitan Area. The Port of Buffalo handled 13 million tons of cargo from Great Lakes and ocean-going shipping in 1970. The Greater Buffalo International Airport which is serviced by six airlines, handled 151,950 scheduled and non-scheduled flights with a total of two million passengers in 1970. The 1970 SMSA population was 1.3 million.

1.3.7 Rochester (Planning Subarea 5.1)

Rochester, the third largest city in New York State, is a world leader in the manufacture of precision goods. It is served by five railroads and three airlines. Rochester-Monroe County Airport serviced 1,353,371 passengers in 1968. The Port of Rochester handled 0.4 million tons of freight traffic in 1970. The 1970 SMSA population was 0.9 million.

1.3.8 Foreign Trade Zones

There are now three foreign trade zones in the area of the Great Lakes. They are Toledo, Ohio; Bay City, Michigan, and Sault Ste. Marie, Michigan. Data on these foreign trade zones are presented in tabular form.

The major commodities in the Toledo zone included zinc, aluminum, liquor, tools, vehicles, and steel. Located within 500 miles of Toledo are 50 percent of Canada's population, 67 percent of U.S. population, and 75 percent of the U.S. buying power. In 1968 the Seaway, through the Port of Toledo, added $124 million to the business life of that area. It also increased the net yield on grain by six cents per bushel to farmers within 150 miles of the port.

1.4 Mining

The abundance of iron ore and limestone near or on the shore lines of the upper Lakes and the high quality coal within 200 miles of the southern Lake ports constitutes an incomparable resource combination. The proximity of these raw materials to the Lakes and resulting potential for their low cost waterborne transportation to steel mills is a circumstance of paramount economic importance.

The Marquette and Menominee iron ranges in Michigan, the Gogebic Range in Michigan and Wisconsin, the Vermilion Range in Minnesota, and Minnesota's famour Mesabi Range have constituted the major source of iron ore in the United States. In 1953 the iron ore production reached a peak of nearly 100,000,000 net tons, which was approximately three-fourths of the total United States production for that year. Shipments from these mines to consumers have since declined to approximately 75,000,000 net tons annually.

Foreign Trade Zone No.	Location	Year Opened	Persons Employed	Movement of Merchandise FY 72: Received $\$10^6$	Received Tons-10^3	Forwarded $\$10^6$	Forwarded Tons-10^3
10	Bay City	1971	n/a	0.05	0.030	0.012	0.006
8	Toledo	1961	44	16.5	37.3	16.1	44.0
13	Sault Ste. Marie	1973[1]	---	---	---	---	---

[1]Approved

SOURCE: 31st Annual Report of Foreign Trade Zones Board to Congress, U.S. Government Printing Office.

While the once abundant high-grade ores of the Mesabi Range are dwindling, there remain tremendous reserves of lower grade deposits, called taconite, of which less than one-fourth is iron. A process is now used in the vicinity of mines on this range that separates iron from waste and concentrates it into pellets consisting of nearly two-thirds iron (approximately 62 percent). Beneficiation processes are also used at mines in Michigan, at Steep Rock in Ontario, and in Labrador. Beneficiation reduces the amount of iron ore shipped and stockpiled at the steel mills, and increases the efficiency of the blast furnaces.

The Steep Rock Range, an important Canadian source of iron ore, is situated within the Basin near Atikokan, Ontario. The mines are under the lake bed. A portion of the Lake had to be drained and other difficulties had to be surmounted before mining operations could begin in 1945. The ore is loaded aboard lake freighters at Thunder Bay for shipment to Canadian and United States consumers.

However, the Labrador region produces the major portion of Canadian iron. In 1970 iron ore accounted for 15,119,000 net tons (98 percent from Labrador) or approximately 30 percent of the cargo tonnage transiting the Seaway. This is nearly three times the average annual ore tonnage transited during the first five years of the Seaway existence.

1.5 Manufacturing

According to the Bureau of the Census Origin-Destination Study, "about 60 percent of the 1956 tonnage of exports of the selected commodities originated less than 100 miles from the port (including origins in the port area itself). Approximately 75 percent of the general imports of the selected commodities were distributed within the receiving port area, or to areas within 100 miles from the port." (see references 50 and 51). The standard metropolitan statistical areas and the entire State of Michigan, all within 100 miles of Great Lakes ports, had nine major industry groups, each accounting for more than one billion dollars of value added by manufacture in 1958 (Table C9-7) and 12 groups in 1967. These industries produced 80 to 90 percent of the value added by manufacture in these metropolitan areas. The value added by manufacture annually increased by 63 percent in the nine-year period.

On a per capita basis the value added by manufacture in a recent year was $792 in the United States, $928 in the 19-State Great Lakes tributary area, $1,012 in the eight Great Lakes border States, and $1,261 in the seven major port areas. These figures are indicative of the concentration of manufacturing in the Great Lakes area.

Steel is necessary in one way or another to almost all manufacturing. If nothing else, it is required in the tools and machinery used. In the United States, steel production of the Great Lakes Basin is concentrated in the Chicago-Gary area, in the Detroit area, and at points along the south shore of Lake Erie. The Pittsburgh and Youngstown steel centers, outside but adjacent to the Basin, receive most of their ore via Great Lakes transportation. In Canada the steel industry is situated in the Hamilton area at the west end of Lake Ontario, and at Sault Ste. Marie. The Canadian steel output in the Great Lakes Basin is a major part of Canada's total. In the United States, mills of the Great Lakes Basin produce approximately one-half of the nation's total. If the Pittsburgh and Youngstown areas were part of the Great Lakes Basin, the steel output would be approximately three-fourths of the nation's total.

1.6 Agriculture

Waterborne commerce on the Great Lakes serves agricultural areas well beyond the limits of the drainage Basin, particularly the grain-producing areas in Canada and the United States far to the west of the Great Lakes. In 1970 approximately 18,858,000 net tons of east-bound agricultural products, mainly wheat and other grains, passed through the locks at Sault Ste. Marie. Approximately 2.2 million tons of this were shipped directly overseas, and 14.9 million tons were shipped to Canadian ports along the St. Lawrence River (primarily for transshipment overseas).

The Seaway has provided an excellent low-cost route for exporting surplus agricultural products. Most of the Seaway grain has its final destination overseas. It provides either a back-haul cargo for the lakers bringing iron ore from Labrador to Quebec or to steel mills in the Great Lakes Region, or full or partial cargoes for a third or more of the outbound overseas ships.

Various processed agricultural products, such as pelletized animal feeds and meal, have entered the world's market largely due to the

TABLE C9–7 Rank and Value Added by Manufacture in 1958 and 1967 for Major Industry Groups with More Than One Billion Dollars Reported for Areas Within 100 Miles of Great Lakes Ports[a]

SIC Code No.	Industry Description	Value Added by Mftg. ($1,000,000)	Percentage Distribution	Percentage of U. S. Total
			1958	
	Total All Industry Groups	33,654	100.0	24
	Total Selected Industry Groups	26,307	78.2	26
33	Primary metals	4,897	14.4	42
37	Transportation equipment	4,481	13.3	29
35	Machinery, excl. electrical	3,808	11.5	31
20	Food and kindred products	3,026	9.0	17
34	Fabricated metal products	2,789	8.3	30
36	Electrical machinery	2,697	8.0	26
28	Chemicals & related prod.	1,980	5.9	16
27	Printing and publishing	1,587	4.7	20
38	Instruments & related prod.	1,039	3.1	36
	Other industry groups	7,346	21.8	18
			1967	
	Total All Industry Groups	61,731	100.0	24
	Total Selected Industry Groups	54,522	88.4	24
35	Machinery, excl. electrical	8,928	14.5	32
33	Primary metal industry	8,603	13.9	43
37	Transportation equipment	8,055	13.0	29
34	Fabricated metal products	6,344	10.3	35
36	Electrical machinery	4,621	7.5	19
20	Food and kindred products	4,555	7.4	17
28	Chemicals & allied prod.	3,473	5.6	15
27	Printing and publishing	2,758	4.5	19
38	Instruments & related prod.	2,562	4.1	40
32	Stone, clay, & glass prod.	1,573	2.5	19
30	Rubber & plastic prod.	1,553	2.5	23
26	Paper and allied products	1,497	2.4	15
	Other industry groups	7,209	11.7	10

SOURCE: U.S. Bureau of the Census, U.S. Census of Manufacturers: 1958 and 1967.

[a]Data reported for areas within 100 miles of Great Lakes ports are for Standard Metropolitan Statistical Areas with 40,000 or more manufacturing employees and for the entire State of Michigan. (The significant concentrations of manufacturing in the State of Michigan are all within 100 miles of a Great Lakes port)

Seaway route. Large quantities of foreign aid commodities—powdered milk, flour, corn meal, and other agricultural commodities—also can be shipped economically from ports near the producing centers largely due to the existence of the Great Lakes-St. Lawrence transportation system.

1.7 Income and Employment Generated by the St. Lawrence Seaway

A recent study under the University of Wisconsin Sea Grant Program[35] concluded that the Seaway provides three types of economic benefits: it reduces transportation costs for mid-American foreign commerce; it generates increased economic activity at the lake ports; and it extends the range of mid-American manufacturers' marketing possibilities.

That study considered the St. Lawrence Seaway to be one of the most important factors in an increased mid-American export trade. Regional income-employment multipliers were calculated as an approximation of the economic impact of the Seaway on the Great Lakes area. Multipliers for five Great Lakes States are presented in Table C9–8.

Economists recognize that an increase in a region's exports causes an increase in nonlocalized employment, which in turn increases a locality's income. When the income increase is spent, employment grows. For example, in Illinois a change in nonlocalized employment of 100 people causes an increase in localized employment of 164. The ratio of change in total employment to change in nonlocalized employment equals (100 + 164=264)/100 =2.64.

It is interesting to compare this with Hoch's 1959 study of the Chicago area[19], which reported that a one-dollar increase in final demand of any industry generates approximately 3.3 dollars in household income. The higher multiplier (3.3 compared to 2.64) is attributed to Hoch's inclusion of the nonmanufacturing sector.

A study by Gadzikowski in 1963[11] took into account the nonmanufacturing and agricultural sectors and showed a multiplier of 2.52. The manufacturing portion of the same data yields a multiplier of 2.02, which approximates the 1.99 for Michigan shown in Table C9–8.

Regional multipliers are used for determining the gross effects of changes in exports on income and employment within the region. Regions with large multipliers tend to be less stable economically, since small changes in exports produce large swings in total regional income and employment. More stable regions are characterized by smaller multipliers.

Using $5 per ton[35] as the average direct income produced from servicing bulk cargo and using $24 per ton for general cargo, a total direct income of $283,000,000 is indicated for 1968 (Table C9–8) for the five States that handle most Seaway trade. Using the multipliers, total direct and secondary income generated is $643,000,000. This income accrues in the form of direct wages and necessary allied services, such as stevedore contractors, customs house brokers, towing companies, ship chandlers, ship repair yards, surveyors, and customs officials.

This income can be translated into employment. Using $7,500 as an approximation of the

TABLE C9–8 Direct Income Generated by 1968 Seaway Traffic

State	Cargo (1,000 tons) Bulk[a]	Cargo (1,000 tons) General[b]	Direct Income ($1,000) Bulk	Direct Income ($1,000) General	Direct Income ($1,000) Total	Income Multiplier	Total Income
Minnesota[c]	4,634	148	$ 23,170	$ 3,552	$ 26,722	1.89	$ 50,505
Wisconsin[c]	401	445	2,005	10,680	12,685	2.57	32,600
Illinois[d]	2,984	2,549	14,920	61,176	76,096	2.64	200,893
Michigan	1,806	2,279	9,030	54,696	63,726	1.99	126,815
Ohio[d]	13,800	1,459	69,000	35,016	104,016	2.23	231,955
Total	23,625	6,880	$118,125	$165,120	$283,245		$642,768

Source: References 32 and 34.
[a]Includes wheat, corn, soybeans, barley and rye, and both shipments and receipts of iron ore.
[b]Includes iron and steel imports.
[c]Duluth-Superior cargo included in Minesota figures.
[d]Indiana's general cargo and much of its bulk cargo moves through Illinois and Ohio ports.

1968 median income, Seaway cargo directly provided income for 37,770 families in the Great Lakes Region (Table C9-9). Adding the secondary income produces a total of approximately 85,710 families.

These income and employment estimates are only part of the Seaway's economic impact. The resulting growth in exports from the Great Lakes States means increased export income, which is multiplied into an even greater expansion of the Region's total income. This income growth has never been estimated, but it is surely many times greater than the port-related income established in this study. If the nonmanufacturing sector (including agriculture) had been included in the study, the resulting multipliers would have been even greater.

TABLE C9-9 Estimated Employment Generated by Seaway Traffic, 1968 (Families)

State	Direct Employment	Total Employment
Minnesota	3,560	6,730
Wisconsin	1,690	4,350
Illinois	10,150	26,790
Michigan	8,500	16,910
Ohio	13,870	30,930
Total	37,770	85,710

Source: Reference 34.

1.8 Complementary Role of Alternative Transport Modes

The railroads, motor carriers, airlines, barge operators, and pipelines serving the hinterland contributing to the Seaway system provide complementary service for most of the domestic and overseas traffic moving through the Seaway. As partners in the total physical distribution process, they transport freight to and from the Great Lakes ports and inland origins or destinations (see references 2 and 5). References 51 and 53 give further information regarding complementary role of alternative transport modes.

1.8.1 Railroads

The railroads provide the most significant complementary service to the Seaway system. Rail lines, for example, pick up huge quantities of grain, coal, and iron ore at inland locations for movement to lake loading ports. In many cases they receive the same type of commodities at discharging ports for transportation to inland consuming centers.

Although most of the coal currently moving through the seaway system begins its journey by rail, use of all-rail unit trains is more competitive than complementary.

1.8.2 Motor Carriers

The motor carriers serving the Great Lakes Region complement the Seaway system. Trucking lines link important inland areas to the Seaway. For example, the process of gathering grains in suitable quantities for shipment has been accomplished to a great extent by trucks. Motor carriers transport corn and soybeans short distances to Chicago and Toledo from inland consolidation points, and carry general cargo imports between lake unloading ports and inland consuming areas. The transport of general cargo imports inland by truck occurs primarily in the Chicago area, which receives a significant portion of the Great Lakes general cargo imports.

1.8.3 Inland Waterways

Inland waterways, such as the Illinois and Mississippi Rivers, complement the Seaway system by moving coal by barge from southern Illinois mines to power plants in Wisconsin and Michigan via Lake Michigan ports. They also provide a lake-barge channel for Mesabi range iron ore destined for steel plants in the St. Louis area. The Great Lakes are also connected with the New York State Barge Canal at Buffalo and Oswego, New York. The Rideau, Trent, and Ottawa canal systems link this hinterland to the St. Lawrence River. These canals are now used primarily for recreational boating.

1.8.4 Pipelines

There are several crude oil pipelines that complement the Seaway system. Pipelines carry crude oil from the southwestern U.S. and the western Canadian Provinces to refineries located on or near the Seaway. Part of the oil refined there is delivered by lake tankers and tank trucks to industrial users and individual consumers.

1.9 Competition in the Great Lakes Basin

1.9.1 Regional Competition

The Seaway is affected by a classic example of the regional competition that has characterized development of this country. The major U.S. ports on the Atlantic, Pacific, and Gulf coasts have certain operating advantages over Great Lakes ports. Vessels calling at coastal ports do not encounter the length or beam limitations imposed by the Seaway. Coastal ports also have a year-round season. Controlling channel depths of 35 feet generally prevail at major ports along the Atlantic and Gulf coasts, and they range up to 42 feet at Baltimore and Mobile, and 45 feet in portions of New York and Norfolk harbors. On the other hand, Atlantic and Gulf coast ports are farther from midwestern shipping and receiving areas than Great Lakes ports. (See references 10 and 53.)

1.9.2 General Cargo

Competition for the Seaway system's import-export overseas general cargo among alternative modes of transportation is and will continue to be intense, especially in container traffic. The Canadian National Railroad, in conjunction with containership operators and port interests, is operating a coordinated, intermodal container service connecting the continental interior lake ports of Chicago, Detroit, and Toronto with Montreal and Halifax. This is accomplished by means of high-speed rail and, if volume warrants, unit trains. With assistance from its U.S. subsidiary, the Grand Trunk Western Railroad, the Canadian National can divert a significant volume of containerized general cargo through Chicago, Detroit, and southern Ontario, on its way overseas. This traffic comes not only from steamship operators serving the Great Lakes-St. Lawrence Seaway system, but also from U.S. railroads serving the North Atlantic ports of New York, Baltimore, and Norfolk. Similarly, the Canadian Pacific railroad is operating a high-speed container rail service, including unit trains between Saint Johns, Quebec, and Montreal, where connecting trains also service the major southern Ontario and U.S. midwest market areas of Chicago and Detroit.

Canadian motor carriers and package freight vessel operators appear to be falling behind Canadian railroads in moving export-import containers to and from southern Ontario markets via Montreal.

United States rail and motor carriers also compete with the Seaway system for overseas general cargo originating and terminating in midwestern markets. This competition and that of the more efficient East coast and Gulf ports have caused services to decline significantly on the Great Lakes. When the Seaway opened, 28 major shipping groups and many smaller ones called at Great Lakes ports. The number of major lines is now down to 10 and could drop even lower. The number of general cargo services has dropped from 60 to approximately 20 in 1973.

1.9.3 Bulk Cargo

Because dry bulk commodities are usually of low value, transportation costs comprise a high percentage of their selling price. Major carriers competing for bulk commodities moving through the Great Lakes Region are the lake vessel operators, rail lines, barge carriers, and pipelines. These carriers can transport sizable volumes of bulk cargo over substantial distances at low costs per ton-mile by using equipment capable of handling large loads. Motor carriers are more commonly used for short-haul bulk movements because they tend to become less competitive as distance increases.

Approximately 90 percent of the Seaway's total traffic is bulk cargo, consisting primarily of iron ore, coal, limestone, grain, and fuel oil. With the exception of grain, most of the bulk traffic is domestic (both originating and terminating within the Great Lakes-Seaway system).

The pipelines and railroads that parallel the Seaway system and serve the same general territory are the major competitors for domestic bulk traffic. Although pipeline service in the Seaway region handles crude petroleum, refined oil products, and natural gas, it only competes directly with the Seaway for refined oil products. Because of its viscosity and contamination potential, heavy fuel oil is generally unsuitable for pipeline transportation. As a result, most of the fuel oil movement in the Great Lakes Region occurs on the Seaway.

Railroad competition within the domestic bulk market manifests itself largely in the use of unit trains, especially for moving coal to electric utilities. Currently, more than 40 percent of the coal used by utilities is carried by unit trains.

Generally, unit train movement of domestic iron ore costs more than rail/lake transportation. However, in certain locations where water transport is unavailable or significantly less direct than all-rail movement, or if ore must be transported during the closed navigation season, rail transportation is often economically attractive. On the other hand a recent study by John Sward for Pullman Incorporated[38] proposed that moving iron ore by unit train from Minnesota is less costly than constructing new vessels to replace the aging bulk carrier fleet.

Although Quebec-Labrador iron ore can be transported via the Atlantic coast ports of Philadelphia or Baltimore to the Pittsburgh steel comsuming area by rail, its cost is still too high to attract tonnages from the traditional rail/water Seaway system.

In 1970 Australian iron ore was delivered to the Pittsburgh area steel plants at costs per iron unit that were competitive with pellets from Minnesota. Philadelphia and Baltimore receive iron ore in 70,000 to 80,000-ton vessels. There are plans to dredge the channels at Baltimore so that vessels of 110,000 to 120,000-tons capacity can deliver ore at prices competitive with Minnesota iron ores.

The foreign ores are attractive because of their high grade which is 68 percent iron and 3 to 4 percent silicone dioxide. In addition, pig iron production costs and "Free on Board" mine prices are lower for natural ores than for Minnesota-produced pellets. Because of the availability of bulk cargo ocean vessels, ocean vessel transportation rates were exceptionally low at the time the ore sales contracts were negotiated. However, these rates are changeable. The closing of the Suez Canal changed the trade routes for world oil transportation, and the crisis in the Middle East has reduced the supply of oil. Pollution controls and increasing demands for coal, oil, gas, and atomic energy have multiplied the demand for bulk ocean transportation.

As a result, ocean freight rates have increased by 100 percent or more. Shipyards of the world, other than the U.S. yards, are fully committed to new construction, vessels of 300,000 tons are in operation and 500,000 tonners are being built. For the present, the competition has eased but ocean shipping rates can reverse at any time.

Because domestic limestone is a low-value commodity that cannot absorb heavy transportation costs, many production and consumption points in the Great Lakes Region are located at or very near lakeside. As a result, limestone is transported only by lake vessels.

The Great Lakes-St. Lawrence Seaway is primarily an internal bulk shipping system. The Seaway does not face exceptionally strong competition from other modes of transport for its domestic bulk cargos, except for coal.

1.10 Transportation Technology, Problems, and Solutions

1.10.1 General

In recent years transportation equipment has become more and more specialized.[8] Containers, while designed especially for a certain commodity, are adaptable enough to carry a similar commodity on the return trip. Although the demand for specialized equipment continues, the accompanying growth in vehicle size has just about run its course, except in ocean-going vessels. The growth is being impeded by the new concern for preserving the environment.

Present technological developments and innovations of inland modal carriers appear to be more competitive than complementary in relation to the Seaway system.

1.10.2 Railroads

1.10.2.1 Technology

The railroads are using larger unit train cars to carry bulk grain and coal at low rates to coastal ports, but not to lake ports. They are also using container and trailer trains to expedite the transport of general cargo moving from the Midwest to eastern ports.

The railroads have done little to increase direct use of the Great Lakes Seaway system. They have neither extended their service nor established through-rate structures, nor have they offered lake ports the service and time privileges provided to coastal ports.

1.10.2.2 Problems

The major problems hindering development of the railroads in the United States are:

(1) Capital investment has been insufficient and improvements to existing facilities are not taking place fast enough. Railroads must compete with modes of transportation that benefit directly or indirectly from government research and subsidies.

(2) Restrictive labor practices still plague the railroad in certain areas.

(3) Railroads contend that they could operate with greater efficiency if they owned trucks, barges, and ships, but such ownership is restricted.

In Canada some of these problems do not exist since there are virtually only two big companies, the Canadian Pacific and the Canadian National. Multi-modal ownership already exists. However, Canadian railways are faced with unprofitable passenger traffic, and are having difficulty discontinuing it.

1.10.2.3 Solutions

Railroad problems are far from being solved. Their complete resolution will be a long-term task. At one time railroad management opposed any aid except tax reliefs or incentives and depreciation allowances. Now the government is beginning to understand the railroads' problems and the industry is becoming less rigid about the forms of government aid or cooperation it will accept. Evidence of this is the faster depreciation schedules for railroads and the emergence of Amtrak to alleviate deficits in passenger traffic.

It has been suggested that the best way for the government to aid railroads would be to own, maintain, and improve the tracks and stations or rights-of-way, and then charge railroads for use. This, it is claimed, would be consistent with government's treatment of other forms of transportation.

1.10.3 Inland Waterways

1.10.3.1 Technology

Ocean-going barge carriers and mini-ships could be used on the Great Lakes-Seaway system. The lighter-aboard-ship or LASH concept, employing lift-on/lift-off containers has been successfully introduced in the Gulf-Western European trade. The first of three Lykes SEABEE barge carriers became operational for overseas service in the Gulf during 1971. The versatile LASH barges, such as those carried on the *Acadia Forest* serving the Gulf, have a capacity of 370 long tons each and a maximum draft of 8½ feet, which enables them to be loaded or unloaded at inland river sites selected by the shipper. A LASH ship's flexibility allows it to carry containers as well as breakbulk cargoes, in addition to dry and liquid bulk cargoes. The mini-ship is another innovation that has been recently introduced successfully between Mississippi River ports and Central American ports.

These innovations give the inland shippers of container cargo the choice of either using LASH lighters or loading directly onto a small vessel capable of navigating both shallow rivers and the deep seas. With containerization the shipper has a single bill of lading. He avoids dealing with a railroad or trucker, and paying wharfage or stevedoring changes for transfer of containerized cargo at ocean ports.

These innovations in inland barge operations have yet to penetrate the Great Lakes.

1.10.3.2 Problems

The inland water carriers are generally free of serious problems. However, possible future problems are:

(1) Government imposition of user charges to offset the cost of navigation improvements and maintenance works would cause an increase in freight rates and impair the industry's present competitive position.

(2) Transfer of responsibility for waterway improvements and maintenance from the Defense Department to a civil department would be regarded by the industry as a possible limitation on future growth of the industry.

(3) The industry would regard any government move to permit multi-modal ownership as a threat to their future prosperity.

1.10.3.3 Solutions

Future government legislation will determine what the user charge policy for all modes of transportation will be. It will determine whether there is a move to multi-modal ownership and whether the government's encouragement of mass transit schemes will divert funds from the rights-of-way of other systems, such as waterways and highways. However, the waterways already completed or approved should allow a steady expansion of barge and lake vessel traffic for at least the next 10 to 15 years.

1.10.4 Airlines

1.10.4.1 Technology

International air freight traffic has been increasing at more than 15 percent per year. Airlines now carry 9.3 percent of the value but only 0.2 percent of the tonnage of U.S. exports and imports. Yet, more than 50 percent of cargo capacity is going unused. Only 30 percent of airline manpower is used and terminal facilities remain idle nearly 20 hours a day.

Larger and more economic aircraft such as the 747 assure continued increases in high value traffic, but they are unlikely to affect ocean shipping in the foreseeable future. Air carriers will play an increasing role in direct service across the Lakes, encouraged by the reciprocal agreement (1965) authorizing direct carrier service between the U.S. and Canada.

1.10.4.2 Problems

Although air traffic will continue to be used primarily for passengers there will be more and more all-freight aircraft. Major problems are:

(1) Construction and financing of efficient freight terminals capable of handling heavy unit loads (containers) could be accomplished at a limited number of key points without excessive capital expenditure, but a comprehensive network will be very costly.

(2) Congestion on the ground to and from airports, in the airlanes, and at airports could cause the government to discourage or at least not to accelerate construction of major air freight facilities at busy airports.

(3) International agreements and regulations about scheduled air routes will affect economical operation, and perhaps prevent two-way loads.

1.10.4.3 Solutions

Continued research and development of vertical takeoff and landing (VTOL) and short takeoff and landing (STOL) aircraft should encourage air transport of freight and passengers. Another innovation is the space-shuttle craft, now under study by NASA. The present concept comprises an initial booster vehicle and a smaller cargo or passenger vehicle. The booster would put the smaller vehicle in orbit and then return to base. The smaller vehicle would continue in orbit to its destination and then land like a normal airplane. Such space-shuttle craft could travel half way around the earth in less than an hour. Continued development of aircraft and more efficient systems for handling passengers and cargo would alleviate crowding in both the air and on the ground.

1.10.5 Motor Carriers

1.10.5.1 Technology

The motor carrier industry has become this nation's top revenue producer in the field of transportation. This is because it provides faster, more personalized service than any other form of transportation. However, the size of motor carrier equipment has not increased substantially. The trend has been toward specialized equipment with a number of uses.

Ecology improvement programs will impinge on the trucking industry because of the resulting legislation, such as laws restricting pollution in exhaust fumes. The Department of Transportation has stated that expressways that would harm the environment will not be built.

Trucks have not taken full advantage of what the Seaway could offer their primarily short-haul services. They have neither initiated nor supported interlake container and trailer services, which are standard operations in the coastal and offshore trades.

1.10.5.2 Problems

Major problems in the motor carrier industry will have a greater impact in the future than they have had in the past. Problems intensify as the industry becomes larger and national population grows. Major problems are:

(1) In this labor intensive industry it is difficult to increase productivity in the face of increasing labor costs. Limitations on the dimension and weight of truck rigs will not allow significant increase in load capacity. This problem could either upset the present net revenue situation in the industry or lead to increases in freight rates, which might be enough to make some shippers switch to other forms of transportation.

(2) Delays caused by congestion in ur-

banized areas are having an economic effect on pickups and delivery. The automobile owner's resentment at sharing the road with trucks grows as congestion increases. Separate routes would be ideal but very expensive.

(3) The industry may be faced with increasing charges to offset the rising cost of highway construction and maintenance.

1.10.5.3 Solutions

There are no short-term solutions for the trucking industry's problems, but there are some longer-term measures that can help. The following could contribute to relief of congestion and consequent delays:

(1) Metropolitan development and planning, in the form of efficient mass transit systems in urban areas will keep more private cars out of these areas. All-commercial truck routes around a city, coupled with collecting and delivery centers near the city, would reduce the number of trucks moving partial loads. The automated highway could greatly increase highway capacity and ensure a smoother flow. Building modification and design to permit efficient off-street loading and unloading and increased night time service could also help alleviate urban traffic congestion.

(2) Little can be done to alleviate the crowding caused by rapidly growing numbers of private cars and trucks. However, closer working relations between railroads and trucking companies to ensure that piggybacking provides service efficiency similar to truck service for distances of 200 miles or more will help alleviate crowded highways.

1.10.6 Pipelines

1.10.6.1 Technology

Pipelines have been improved in size, automation, mixing in transit, and joint company ventures. Currently a 30-inch pipeline can deliver major quantities of crude oil at lower cost than any tanker that can be put into Great Lakes use with present depth limitations. Whenever the commodity is soluble or finely ground and in great volume (industrial chemicals, pulp, sulfur, and coal slurry), the direct-hauling pipeline is a potential alternative to waterborne movement.

Pipelines may also contribute to lake cargos by piping in products requiring dispersed inland distribution or overseas movement. A new system has been developed to move iron ore from mine to mill by a combination of slurry pipeline and bulk ocean transportation. However, it is unlikely that slurry pipelines will bring iron ore to Great Lakes steel mills. Further innovations in transporting dry bulk commodities sealed in containers through pipelines add to this mode's potential influence in the field of transportation.

1.10.6.2 Problems

The oil pipeline industry is singularly free of the type of pervasive problems that affect some other modes. Technological problems, such as leaks and spills, and combating corrosion, and the special problem of constructing a safe pipeline in the permafrost of Alaska will probably be overcome by advanced technology.

Perhaps the biggest problem of the industry is guarding against oil pollution caused by accidents.

1.10.6.3 Solutions

Although oil pipeline companies will be subject to restrictions in some of their operations, as they were off the California coast after the Santa Barbara oil leak, and as they were in getting permission to construct a pipeline from Prudhoe Bay, there is little doubt that technology will overcome these problems. However, risks of spills can never be entirely eliminated.

1.11 Comparison of Great Lakes-St. Lawrence Seaway Navigation System with U.S. Coastal Ports

1.11.1 Coastal Ports

Major U.S. ports on the Atlantic, Pacific, and Gulf Coasts enjoy a distinct operating advantage over Great Lakes ports because they can accommodate larger vessels on a year-round basis.[53] Vessels calling at coastal ports do not encounter any length or beam limitations except possibly in narrow or winding approach channels or at pier terminal facilities.

In addition all major seaboard ports currently have greater depths in their harbor channels and alongside berthing facilities than Great Lakes and Seaway ports. As illustrated in Table C9-10, controlling channel depths of 35 feet generally prevail at major ports in the Atlantic and Gulf coasts. Depths of 35 to 40 feet are generally available in the principal Pacific coast ports, though Los Angeles has a 51-foot entrance channel and Long Beach has a 52-foot entrance channel for accommodating supertankers. Puget Sound has depths of 100 feet.

Because most U.S. seaboard ports have controlling depths between 35 and 40 feet, they can handle a significantly higher percentage of the total world fleet at full draft than can Great Lakes ports. As shown in Table C9–11, Atlantic, Gulf, and Pacific coast ports can potentially accommodate at full drafts ranging from 32 to 42 feet, approximately 84 to 97 percent of the world's 19,570 ocean vessels (1969). Great Lakes ports can handle only 47 percent of the world fleet at a 26-foot draft.

Because most general cargo vessels and containerships can be loaded in ocean ports at or near their maximum drafts, present seaboard harbor and berthing depths appear adequate to handle existing and most future containerships, whose drafts are just beginning to exceed 40 feet. Only crude oil, oil-bulk-ore, and certain dry bulk carriers constructed in the last decade pose an accommodation problem for U.S. coastal ports.

The size of bulk vessels capable of berthing at most U.S. ports fully loaded is limited to the general range of 50,000 to 80,000 tons. Only the ports of Los Angeles, Long Beach, and Seattle can accommodate tankers up to approximately 110,000 dwt at berth. The upward trend in bulk vessel size has produced over 200 tankers and bulk carriers exceeding 100,000

TABLE C9–10 Channel Depths of Selected Principal U.S. Ocean Ports

	Channel Depths[a]				
	Controlling[b]		Authorized[c]		
Name of Port	Main Entrance Channel (ft.)	Main Harbor[d] Fairways (ft.)	Main Entrance Channel (ft.)	Main Harbor[d] Fairways (ft.)	Mean Tidal Range (ft.)
Boston, Mass.	38	40–35	40	45–35	10
New York, N.Y./N.J.	45	44–30	45	45–30	5
Philadelphia, Pa.	40	37–22	40	40–37	6
Baltimore, Md.	42	42–21	42	42–27	1
Norfolk, Va.	45	35–31	45	40–35	3
Charleston, S.C.	35	34–30	35	35–30	5
Mobile, Ala.	42	38–24	42	40–25	2
New Orleans, La.[e]	40	35–27	40	36–32	0
Houston, Tex.	37	37–34	40	40–36	0
Los Angeles, Calif.	51	51–35	51	51–35	4
Long Beach, Calif.	52	52–35	52	52–35	4
San Francisco, Calif.	50	39–31	55	40–35	4
Portland, Oreg.	35	35	40	40	2
Seattle, Wash.	Unlimited	34–28	Unlimited	34–30	8

[a]Based on 1967–1968 data. Chart datum plane for Atlantic and Gulf coast ports is mean low water, and for Pacific coast ports it is mean lower low water.

[b]Controlling depths are often less than original or authorized (project) depths due to silting, shifting sand bars, and similar problems.

[c]Authorized depths include original or project depths in channels which are part of Federal deepwater channel improvement and maintenance projects developed over the years under Congressional authorization in accordance with the needs of navigation as recommended by the Chief of Engineers, U.S. Army. In general, channel depths authorized in United States ports have been based on actual drafts of vessels using the channel, plus sufficient water under the keel to insure safe and efficient operation of these vessels when operating under their own propulsion.

[d]Includes main navigable channels as well as branch or auxiliary channels used customarily by ocean-going vessels when proceeding from the open sea to their berth or from one berth to another within the harbor area.

[e]Diurnal range of tide during low-river stages averages 0.8 foot.

SOURCE: Division of Ports, Maritime Administration.

TABLE C9–11 Potential U.S. Ocean Port Capability of Accommodating World Merchant Fleet at Selected Drafts

		Draft (32' or less)		Draft (35' or less)		Draft (37' or less)		Draft (39' or less)		Draft (42' or less)	
	Total World Fleet	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total	Number	Percent of Total
Combination Passenger Cargo Vessels	931	925	99.36%	930	99.89%	930	99.89%	930	99.89%	931	100.00%
Freighters	11,820	11,677	98.79%	11,810	99.91%	11,815	99.96%	11,818	99.98%	11,819	99.99%
Bulk Carriers	2,748	1,636	59.53%	2,095	76.24%	2,296	83.54%	2,469	89.84%	2,612	95.05%
Tankers	4,071	2,278	55.95%	2,747	67.47%	3,026	74.33%	3,341	82.06%	3,648	89.60%
Total Fleet	19,570	16,516	84.39%	17,582	89.84%	18,067	92.32%	18,558	94.83%	19,010	97.14%

Source: Office of Ports and Intermodal Systems, Maritime Administration - Developed from Merchant Fleets of the World--Frequency Distributions, December 31, 1969.

dwt. Another 250 were under construction or on order at the beginning of 1970. By 1980 large crude oil tankers and dry bulk carriers ranging from 100,000 to 250,000 dwt are expected to be operating in the U.S. bulk foreign trades.

U.S. ocean ports, the Federal government, and bulk carriers will have to develop adequate terminal facilities for these larger, economical vessels, which require depths from 50 to 75 feet, in order that bulk-using industries can take advantage of them.

These superships may pose a problem to the 27-foot Great Lakes system because its maximum navigable depth is estimated at approximately 35 feet (see Subsection 2.7.3, Physical Factors Influencing Navigation).

1.11.2 Panama Canal

Coastal traffic is constrained by the Panama Canal, which can only handle ships up to 950 feet long, 106 feet wide, and 40 feet in maximum draft.[30] The maximum tonnage per ship the Canal can handle is approximately 85,000 deadweight tons in ballast or 65,000 tons laden. Approximately 900 commercial ships in the world fleet can not transit the Canal at all and more are being built every day. In addition, approximately 1600 ships can not transit the Canal fully loaded at all times because of draft limitations. These large ships are primarily bulk carriers of ore and oil. Container ships and general cargo ships larger than the Panama Canal locks will probably not be built in significant numbers for many years.

Section 2

GREAT LAKES-ST. LAWRENCE WATERWAY SYSTEM

2.1 General

The Great Lakes-St. Lawrence Seaway system provides a continuous waterway extending 2,342 miles into the heart of North America. For geographical reasons and in order to identify national and international responsibilities for the waterway system, it is described in four parts: the Gulf of St. Lawrence and the lower St. Lawrence River; the upper St. Lawrence River between Montreal and Lake Ontario; Lake Ontario and the Welland Canal connecting Lake Ontario and Lake Erie; and the upper Lakes and connecting channels, which include the waterways between Lakes Erie and Huron, Lakes Huron and Superior, and Lakes Huron and Michigan (Figures C9–2 and C9–3 and Table C9–12). The St. Lawrence Seaway is considered to extend from Montreal to the upper terminus of the Welland Canal in Lake Erie.

2.2 Gulf of St. Lawrence and Lower St. Lawrence River

The Gulf of St. Lawrence extends from the Atlantic upstream 700 miles to Father Point (Figure C9–2). Two entrances to the St. Lawrence are available from the Atlantic, one

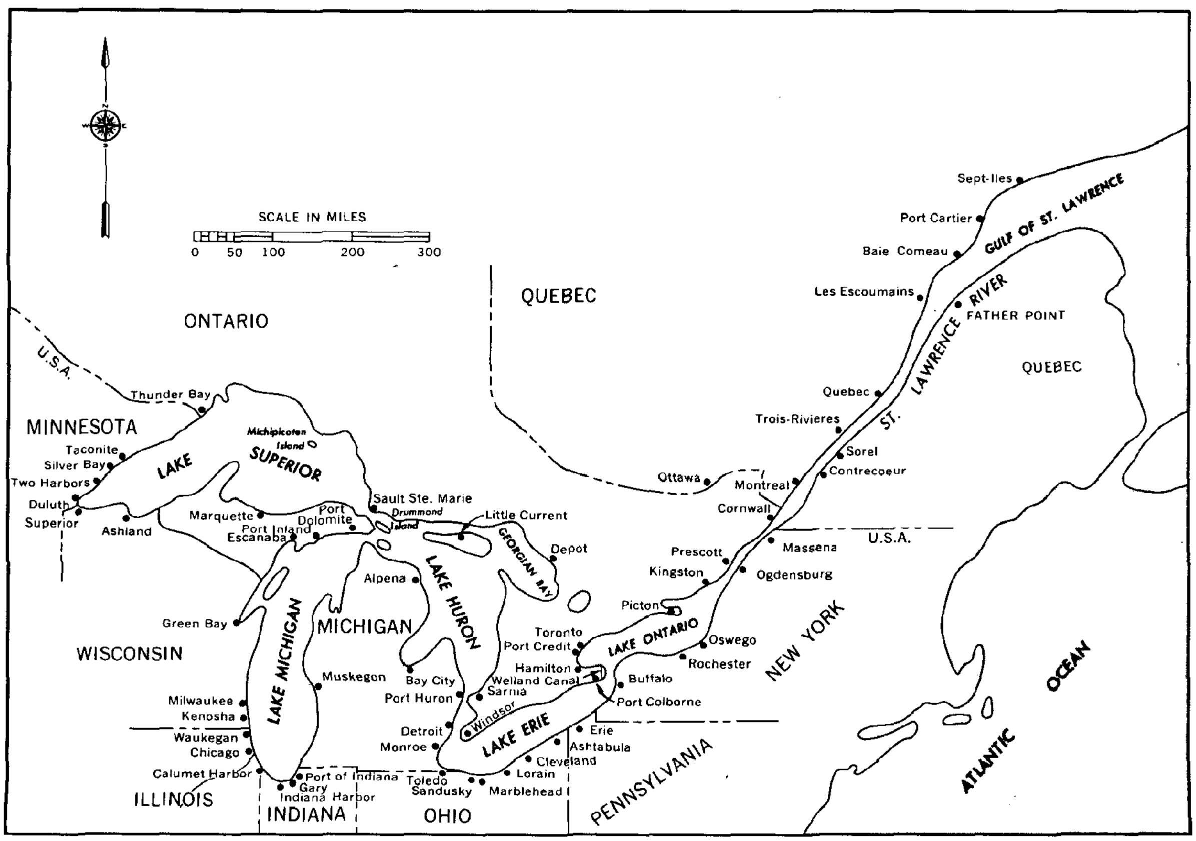


FIGURE C9–2 Great Lakes-St. Lawrence Seaway Navigation System

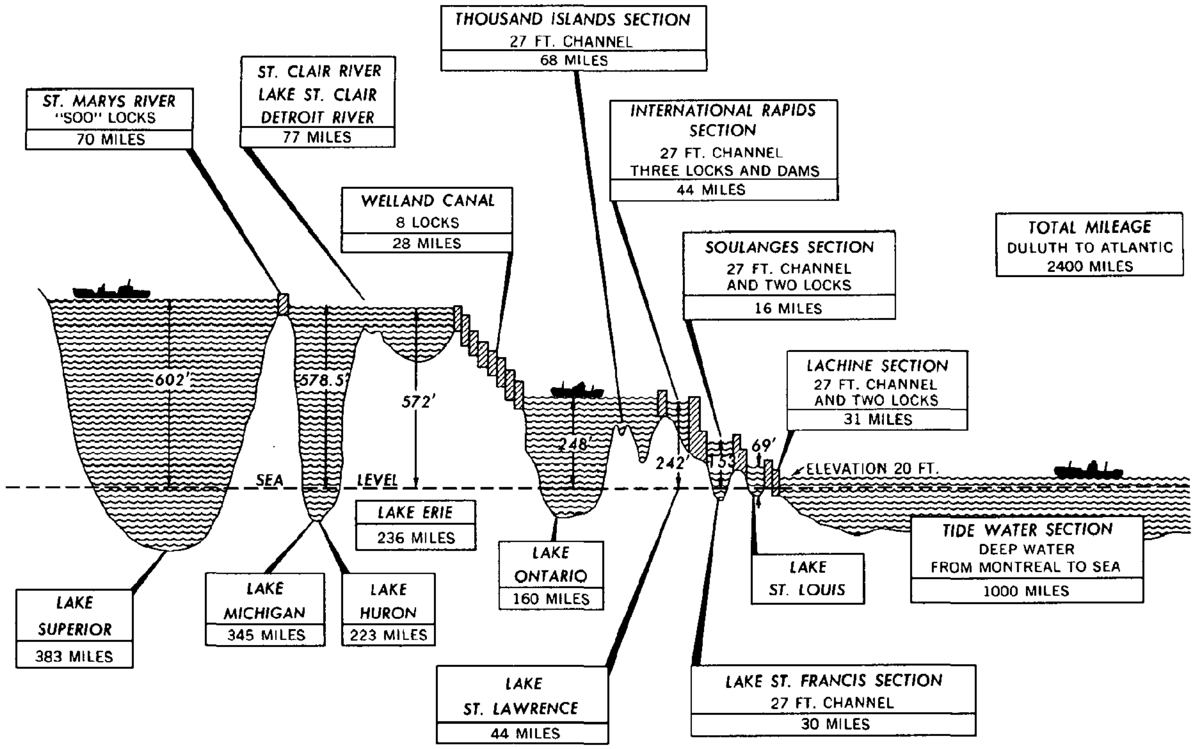


FIGURE C9–3 Profile of Great Lakes-St. Lawrence Seaway

through the Strait of Belle Isle, to the north of Newfoundland, which provides a 12-mile wide passage at its narrowest point, and another to the south through the Cabot Strait, which provides a 60-mile wide passage south of Newfoundland.

The St. Lawrence River mouth is at Father Point, Quebec. In the 340 miles to Montreal, the river level ascends only 20 feet from sea level. The tidal run dissipates approximately halfway between Montreal and Quebec City at the City of Trois-Rivières. The Canadian government maintains a 35-foot channel in the thousand miles of open waters between the Atlantic Ocean and Montreal.

2.3 The Upper St. Lawrence River

The reach between Montreal and Lake Ontario, a distance of 182 miles that ascends a total of 226 feet, is the waterway's greatest obstacle to navigation. It also offers the greatest potential for hydroelectric power development. Rapids and lakes alternate through this section of the river.

The Lachine Rapids are bypassed by a lateral canal 18 miles long containing two locks, the St. Lambert Lock at the lower end opposite Montreal, and the Cote Ste. Catherine Lock 8½ miles upstream.

Lake St. Louis extends upstream another 16 miles to the point where the Ottawa River joins the St. Lawrence River. Continuing upstream, a series of rapids known as the Cascades, Split Rock, Cedar and Coteau Rapids form a total ascent of 82 feet between Lake St. Louis and Lake St. Francis. The rapids in this section of the river are bypassed by a lateral canal 2½ miles long containing two locks, the Upper and Lower Beauharnois Locks. Beyond this artificial channel the river continues upstream for a distance of 14 miles via the Beauharnois power canal, which terminates in Lake St. Francis. All of this section of the river, including Lake St. Francis, is in Canada.

The international section of the river begins at the upstream end of Lake St. Francis. This formerly was a swift-flowing section that ascended 90 feet in the 44 miles to Ogdensburg, N.Y. Once rapids and swift flowing river, this section is now a reservoir, which forms Lake

TABLE C9–12 Physical Dimensions of the Great Lakes-St. Lawrence Seaway

	Lakes and Channels			Locks				
Reach	Open Waters (miles)	Channels & Canals (miles)	Depth (min.) (Ft.)	Number	Year Completed	Size (Ft.) Length x Width	Depth over Sill (Ft.)	Lift (Ft.)
Atlantic Ocean to Father Point, Que.	700	---	---	---	---	---	---	---
Father Point to Montreal	300	---	35	---	---	---	---	---
Montreal to Lake Ontario (includes St. Lawrence Seaway)	189	91	27	5 (Can.)	1958	800 x 80	30	226
				2 (U.S.)	1958	800 x 80	30	226
Lake Ontario to Welland Canal	160	---	---	---	---	---	---	---
Welland Canal	---	27	27	8	1932	800 x 80	30	326
Welland Canal to Detroit River	236	---	27	---	---	---	---	---
Detroit River, Lake St. Clair, and St. Clair River	---	77	27	---	---	---	---	---
Lake Huron, St. Clair River to St. Marys River	223	---	---	---	---	---	---	---
St. Marys River (includes Soo Locks)	70	2	27	2 (U.S.)	1919	1350 x 80	23.1	22
				1 (U.S.)	1943	800 x 80	31.0	22
				1 (U.S.)	1968	1200 x 110	35.0	22
				1 (Can.)	1895	900 x 59	16.8	22
Lake Superior, St. Marys River to Duluth	383	---	---	---	---	---	---	---

St. Lawrence, held back by four power structures. The difference in elevation is overcome by three locks, Bertrand H. Snell, Dwight D. Eisenhower, and Iroquois.

The remaining section of the river extending 68 miles into Lake Ontario is known as the Thousand Islands section. This section is free of rapids, but it contained many rock shoals, which obstructed navigation. These were removed and the channels widened and straightened for navigation.

The controlling channel dimensions for the Seaway from Lake Erie to Montreal include a minimum depth of 27 feet, to permit transit of vessels drawing 25′ 9″ in fresh water.

The seven new locks of the St. Lawrence River (five in Canada, operated by the St. Lawrence Seaway Authority of Canada, and two in the United States, operated by the St. Lawrence Seaway Development Corporation) are all similar in size. These locks can accommodate ships up to 730 feet long and 75 feet wide.

Each vessel must be registered and precleared prior to using the Seaway, as prescribed by the Seaway rules and regulations. Preclearance forms must be filed with the U.S. Seaway Development Corporation or the Canadian Seaway Authority. This form gives pertinent data concerning the dimensions of the ship, its equipment, and the manner in which the toll charges are to be guaranteed and paid. When the form is approved, the vessel is assigned a number which is used in transmitting each of the locks.

It takes approximately seven minutes to raise or lower the water level at Eisenhower and Snell Locks and approximately 22 million gallons of water are used. Figure C9–4 shows a bulk carrier at Eisenhower Lock. In the Iroquois Lock, the water is let in and out by partially opening the upper or lower lock gate. It takes approximately five minutes to open or close any pair of lock gates and operate the fender boom. An average lockage on the Seaway requires 33 minutes from the time the bow passes the approach wall until the stern is cleared of the outermost boom.

Hydroelectric power facilities were developed and are operated by two agencies at

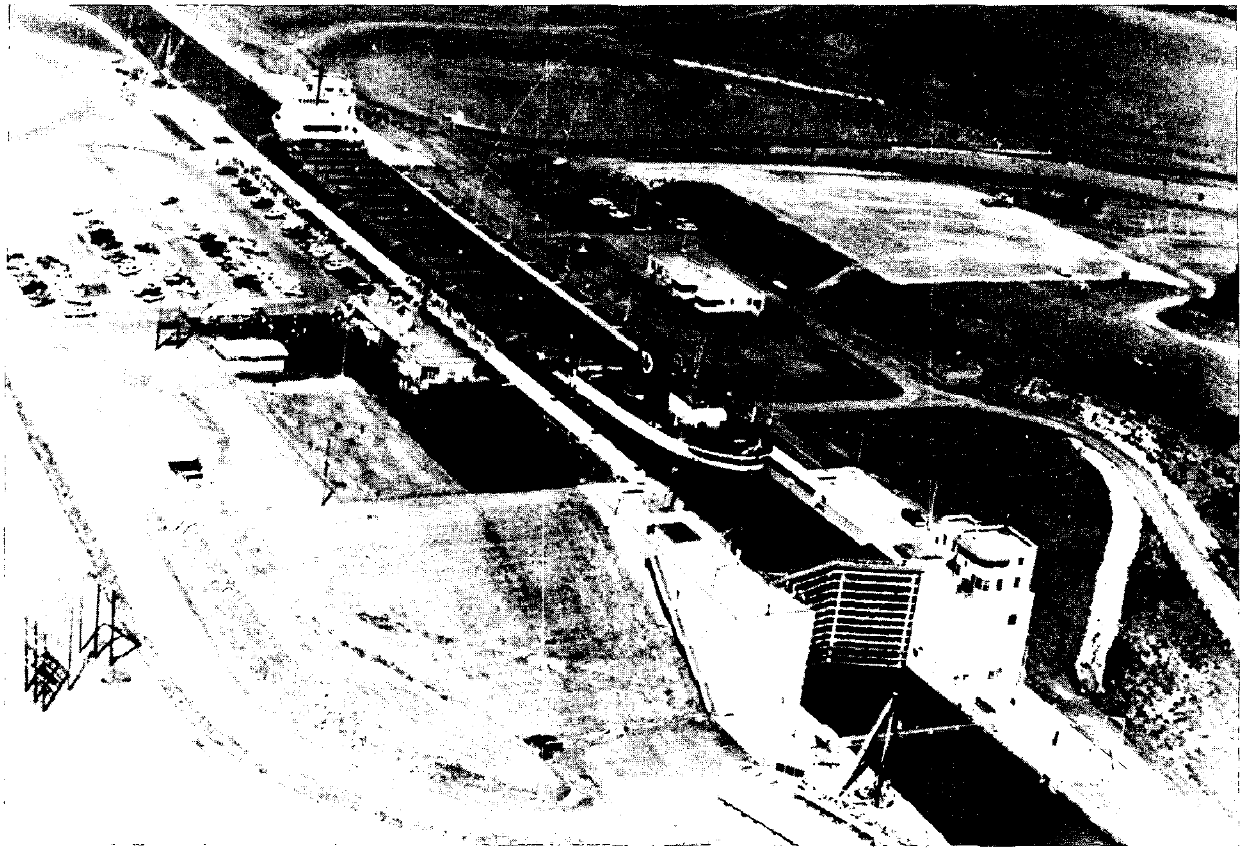


FIGURE C9–4 The *Carol Lake* Bulk Carrier. The *Carol Lake*, a 715 by 75 foot bulk carrier owned by Carryore Ltd., Montreal, Quebec, is shown in the lock chamber at Eisenhower Lock.

State-Provincial level, the Power Authority of the State of New York and the Hydro Electric Power Commission of Ontario. The creation of the power reservoir in connection with extensive channel improvements undertaken and financed by the power agencies, made the simultaneous development of navigation and power economically and physically feasible.

Costs of the St. Lawrence Seaway and Power Project total more than one billion dollars. Operating costs for the navigation facilities are recovered through tolls. The costs for power facilities will be paid by those using the electricity produced. This project was opened to navigation in 1958.

2.4 Lake Ontario and the Welland Canal

Lake Ontario is the smallest of the Great Lakes in area. It is approximately 180 miles long and 50 miles wide. The Welland Canal, 28 miles long, provides a waterway between Lakes Ontario and Erie. It bypasses Niagara Falls and the river gorge with its series of eight locks, which raise or lower vessels 326 feet. The Welland Canal was designated a part of the Seaway by the Canadian Seaway Act, and it is now operated by the St. Lawrence Seaway Authority. The Welland Locks and Canal were completed in 1932 by Canada at a cost of approximately $13,000,000. This original cost will not be recovered from toll revenues. Only part of the cost of operation and new improvements at the Welland Canal are recovered from lockage fees.

Since the opening of the Seaway many improvements have been undertaken to reduce transit time through the Welland Canal. One important addition is the traffic control system inaugurated in 1966, which uses closed-circuit television and telemetry to direct ship movements. A new eight-mile straight channel to bypass the part of the route that is intersected by a number of highway and railroad bridges was completed in 1972. It provides a straighter alignment of the canal and reduces transit time. Other plans propose a new route for the northern third of the canal. It would provide four new locks, each having nearly double the 46.5-foot lift of the seven existing locks (three twin and four single) they would replace.

2.5 Lakes Erie, Huron, Michigan, and Superior

Lakes Erie, Huron, Michigan, and Superior, together with the connecting channels (the Detroit River, Lake St. Clair, the St. Clair River, and the St. Marys River) and the locks at Sault Ste. Marie, form the remainder of the Great Lakes-St. Lawrence Seaway navigation system.

A 27-foot project depth has been available in the connecting channels since June 1962. The St. Marys River project provides a channel for the construction and operation of four locks in the St. Marys River at Sault Ste. Marie, Michigan and one lock at Sault Ste. Marie, Ontario. Here vessels are raised and lowered approximately 22 feet. Figure C9-5 shows an aerial view of the Soo Locks at Sault Ste. Marie. The MacArthur Lock is equal in dimensions to St. Lawrence Seaway locks, but the new Poe Lock (32 feet deep over the sills, 1,200 feet long, and 110 feet wide) can handle ships up to 1,000 feet in length and to 105 feet in beam. These lock depths exceed the channel depths leading to the lock.

2.6 Other Connecting Waterways

The Great Lakes-St. Lawrence System and the Mississippi River Inland Waterway System are connected at the Calumet Harbor and River Project at the south end of Lake Michigan. The 5,000 mile Mississippi River Inland Waterway System services the central part of the United States.

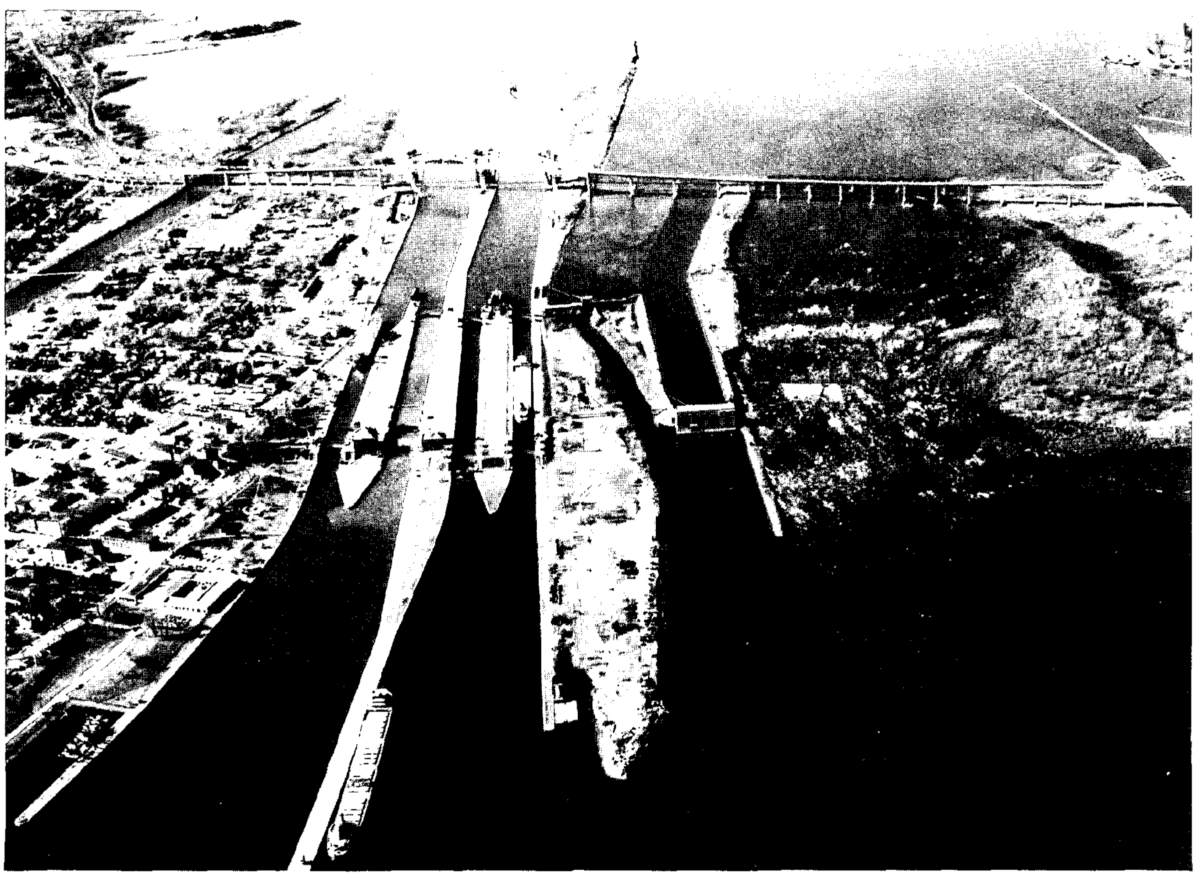


FIGURE C9-5 Aerial View of Soo Locks at Sault Ste. Marie, Michigan

2.7 Physical Constraints Affecting Navigation

2.7.1 General

Navigation on the Great Lakes-St. Lawrence System is affected by a number of physical constraints, but most can be modified to varying degrees by human endeavor.

The fundamental factors are depth of water and influence of climate. Depth of water includes both depths below chart datum and fluctuations in water level. Climate has both long- and short-term impact. The most noticeable impact of climate, a long-term one, is the annual formation of ice on Lakes. Another long-term impact is the fluctuation in lake level due to fluctuation in precipitation rates. Storms characteristic of the temperate zone are short-term climatic impacts.

2.7.2 Water Levels and Flows

The water levels of the Great Lakes vary from year to year, and from month to month during each year. The seasonal high occurs in the summer months, and the low occurs in the winter during the closed navigation season. The variation between the summer high and the winter low usually ranges between one and two feet.

All project depths in the Great Lakes navigation system are given in feet below low water datum (LWD), the plane on each Lake to which Federal navigation depths are referred. Elevations are in feet above mean water level at Father Point, Quebec, a point on the St. Lawrence River near the river transition to the Gulf of St. Lawrence (1955 International Great Lakes Datum). The present low water datum planes for each of the Lakes were established in 1933 from a consideration of the recorded levels since 1860. Low water datum levels were selected to represent average low levels. Average lows and highs over the period of record (1860–1971) are shown in tabular form.

Lake	Avg. Winter low	Avg. Summer High
Lake Superior	-0.1 (March)	+0.9 (Sept.)
Lakes Michigan-Huron	+1.4 (Feb.)	+2.4 (July)
Lake St. Clair	+0.3 (Feb.)	+2.0 (July)
Lake Erie	+1.2 (Feb.)	+2.4 (June)
Lake Ontario	+1.3 (Jan.)	+2.8 (June)

Depths available during the navigation season are generally equal to or greater than project depths, except during extreme low-water years, such as those occurring during the mid-1920s, mid-1930s, and early 1960s. For the connecting rivers between Lakes Superior and Huron, between Lakes Huron and Erie, and for the upper reaches of the St. Lawrence River, low water datum is the sloping surface of the rivers when the Lakes are at their low water datum elevations.

Because an inch of draft represents up to 110 tons of cargo on the large freighters now in use, and 200-plus tons per inch on the new 800 and 1,000 feet ships, any lowering of the water level can cause severe losses in the quantity of cargo moved and in the unit cost of cargo movements. From a navigation standpoint then, it is desirable that water levels be as high as possible and at least as high as LWD.

Water levels also affect speed limits imposed by the Corps of Engineers in the Detroit-St. Clair Rivers and by U.S. Coast Guard in the St. Marys River. Speed and, therefore, time of transit affect the cost-per-ton-mile. Speed limits are temporarily reduced during periods of high water to reduce shore erosion.

2.7.3 Depths

Depths are a major constraint on navigation. With few exceptions, the Lakes proper have ample depth for navigation. It is in the connecting waters and the harbors where depths are a problem. Navigation needs now are well in excess of natural depths in most of these areas. These waters have been dredged to their present controlling depths. Further deepening becomes increasingly difficult as greater depths are needed. For the Great Lakes-St. Lawrence Seaway system, the maximum depth attainable appears to be 35 feet, the depth of the St. Lawrence River channel downstream of Montreal. For inter-lake traffic controlling depths would be the depths that can be obtained in the connecting waterways. The most serious problem area is the St. Clair-Detroit River system where deepening of navigation channels can lower the level of Lakes Huron and Michigan. The deepening effect can be offset to a certain extent by compensating works. However, as channel depths increase, it becomes more and more difficult to provide necessary compensating works. It might be necessary to install a lock system. This could cause congestion because of the density of traffic.

2.7.4 Weather and Ice Conditions

Ice is an inevitable result of the climate of the Great Lakes Region. At this time, there is no known method for reducing formation of ice on a lakewide basis. Limited areas can be protected against ice formation, but in general, navigation through ice cover depends upon available techniques of ice breaking.

During the 3½ to 4 winter months the Seaway is closed money is lost through the immobilization of a large fleet of expensive ships and docks, seasonal employment of crews and longshoremen, stockpiling materials, and rerouting to other means of transport.

The official 260-day shipping season 1972 for the St. Lawrence Seaway, Montreal to Lake Ontario, extended from April 1 to December 15. These are official published dates, not actual operating dates. The Seaway Development Corporation established targets for an official season of 240 days in 1970, 255 days for 1971, 260 days for 1972, 270 days for 1974, and 275 days for 1975. Interlake traffic through the Soo locks generally closes on December 15. However, in 1969 this closing date was extended to January 11. It was extended to January 29 in 1970 and February in 1971.

Overseas commercial navigation interest emphasizes that for maximum benefit extension of the season must be publicized at least 90 days in advance. This permits advantageous scheduling of overseas traffic. Interlake traffic, similarly needs firm dates but with much less lead time.

Vessels that would benefit from an extension of the navigation season are predominantly the dry bulk carriers and the ocean-going general cargo fleet. The latter is a relatively new group of vessels, many of which, by virtue of their ocean-going trades, are equipped for ice operations. In contrast, more than 50 percent of the total available capacity of the dry bulk fleet is in vessels built prior to 1948 and not necessarily suited for ice operations.

Winds and other weather conditions have significant long-term and short-term effects on navigation. Precipitation is the basic source of water supply for the Lakes. Long-term fluctuations in amounts of precipitation cause corresponding fluctuations in lake levels. Wind action also has a major impact on navigation through wind forces acting directly on ships through wave action, and through short-term water level fluctuations. Snow and fog can cause serious visibility problems.

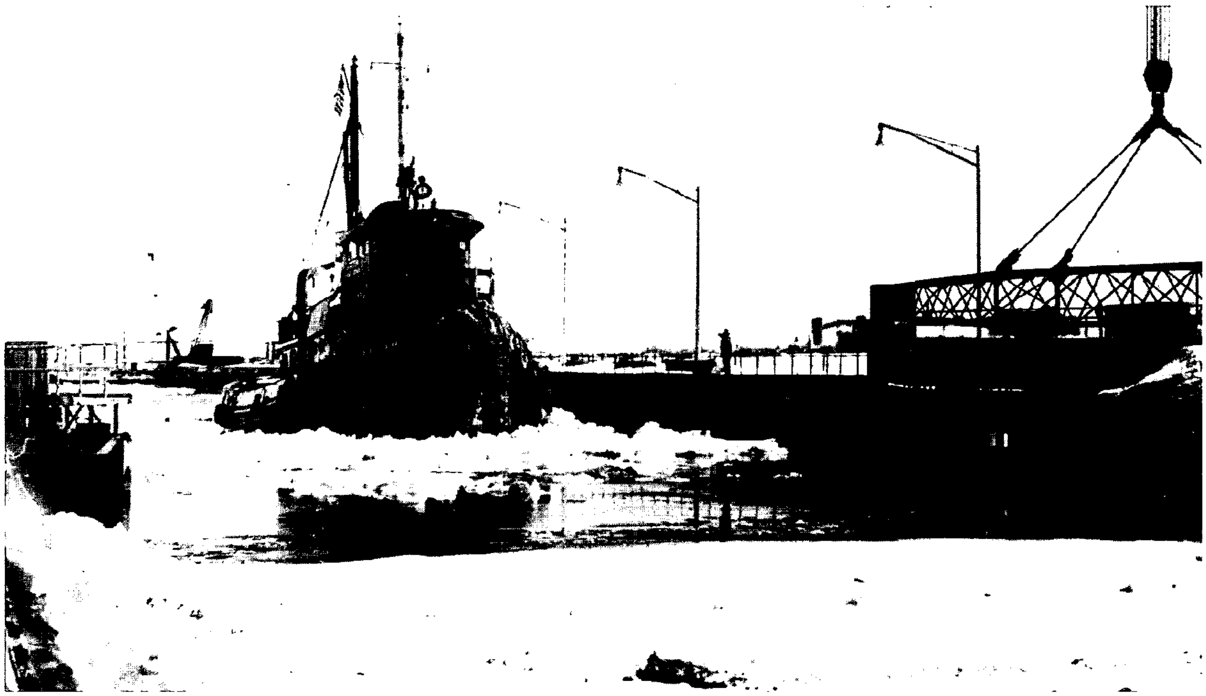
An example of the severe weather that has confronted ships is the famous storm that ripped across Lake Huron and Lake Superior in November 1913. Seventeen ships were either lost or damaged beyond repair and a total of 285 sailors lost their lives. There have been other bad storms, but this is the worst to date.

Another reason for the use of extreme caution during late season operations is the present insurance rate structure. Rates are different for each vessel and are a function of the area of operation, type of cargoes, capability for ice operation, damage record, and many other variables. Ironically, Canadian experience in the Gulf of St. Lawrence has indicated very little hull damage to vessels hard beset. Many insurance companies will not specify a rate structure for operation beyond a four-week late season extension, or prior to a three-week early start of the season. However, attitudes toward winter insurance rates appear to be easing. Figure C9–6 shows an ice-breaking tug.

Wind and weather problems have to be accepted; there is now no significant method to modify their effects. Vessels must be designed to withstand wind and wave forces. Channels and harbors must be designed to permit navigation under all but extreme conditions and to provide shelter for vessels from extreme conditions of wind and wave. Long-term fluctuations of water level can be modified to some extent by control works at the outlets of the Lakes. The effect of short-term fluctuations can be offset by additional deepening of harbors and channels in areas subject to these fluctuations. The development of radar and of electronic navigation aids have partially resolved the problem of navigating in periods of restricted visibility, but passage through confined waterways is still difficult in these periods.

2.7.5 Currents

Currents cause problems in many places. The flow of water from Lake to Lake creates currents in connecting waterways. Short-term fluctuations in lake level cause sudden changes in these currents, and they also cause sudden currents in harbor areas. Normal currents can be alleviated by training works and dredging at the most troublesome locations. Currents due to short-term level fluctuations are greater problems. A navigator may not be aware of them until his vessel is caught and carried off course. These currents are difficult



Courtesy of Saint Lawrence Seaway Development Corporation

FIGURE C9–6 The *Robinson Bay* SLSDC Tug. The tug is shown leaving Snell Lock at Massena, New York, on March 17, 1971, to begin ice breaking in the Wiley-Dondero Canal.

to control. Navigators should be aware that currents can occur and of the conditions that create them.

2.8 Limitations Imposed by Lock Sizes and Channel Depths

2.8.1 General

Since resources were not available to build a new Welland Canal when the Seaway was designed following Congressional authorization in 1954, it was argued that there was no point in building locks at Montreal or in American waters to accommodate ships larger than those which could get through the Welland Canal.[53] Therefore the new Seaway locks were built to the same dimensions as the Welland Canal locks. In 1959 the new Seaway, capable of handling cargoes of approximately 30,000 tons in large bulk carriers, or approximately 20,000 tons in saltwater vessels, was opened.

When the Seaway was under study, during the 1930s and 1940s, such cargo capacity seemed impressive. In fact testimony before Congressional committees even in the late 1940s predicted that the Seaway could successfully serve approximately 85 percent of world shipping then afloat. In World War II a 15,000 to 20,000 ton dry bulk or petroleum cargo ship was reasonably impressive, but now there are ships in the range of 100,000 to 400,000 tons, far beyond Seaway capacity.

Vessels wishing to enter or exit the Great Lakes segment of the Seaway system are limited by the St. Lawrence River and Welland Canal locks to a 730-feet length and 75 feet 6 inches in beam. Poe Lock at Sault Ste. Marie limits the size of vessels sailing between Lakes Superior, Huron, Michigan, and Erie to 1,000 feet long and 105 feet wide. All of these locks have depths over the sills in excess of channel depths leading to the locks, but the drafts of ocean and laker vessels are limited by the channel depths.

The authorized depth of 27 feet in the St. Lawrence Seaway and Welland Canal restricts ocean and lake vessels entering or leaving the system to a maximum safe draft of 25 feet nine inches. In the connecting channels above Lake Erie, a controlling depth of 27 feet below low water datum has been available since 1962 in order to provide a safe draft of 25 feet six inches for lake vessels when the water level is at low water datum.

2.8.2 Length

In 1966 only three vessels in the world merchant fleet exceeded a length of 1,000 feet. In 1970, 81 vessels, practically all tankers, had lengths exceeding 1,000 feet. However, virtually all combination passenger/cargo vessels (96.7 percent) and freighters (99.9 percent) in the world fleet (1970) have lengths less than only 700 feet. In fact as of December 1969, there were only 16 freighters, mostly newer containerships, in the world fleet with lengths in excess of 700 feet. Of 19,570 ships in the world fleet, 92.3 percent had overall lengths less than 700 feet.

Because large tankers are not economical for Seaway use, the limiting 730 foot Seaway length is primarily a problem for the larger dry bulk carriers whose lengths in recent years have increased considerably in the 700 to 1,000 foot range. The majority (85.5 percent) of the world's bulk carriers still have lengths less than 700 feet. While future full containerships are expected to increase in length up to 1,000 feet, very few, if any at all, are anticipated to use the Seaway system instead of other high volume and high revenue worldwide container trade routes.

2.8.3 Beam

The Seaway's vessel beam restriction of 75 feet 6 inches is far more critical than its length limitation in terms of potential vessel accommodation. In recent years increased beams have been characteristic of large bulk carriers and tankers, as well as many new full containerships. Therefore, the Seaway's beam constraint, more so than its length limitation, considerably reduces the capability of the world's bulk carriers (66.9 percent) and tankers (54.9 percent) to transit its existing lock system. Since pipelines serve the Seaway region's crude oil needs, the inability of the Seaway to accommodate the broad-beamed crude oil supertankers is not significant. The internal Lake distribution of refined petroleum products is far more suited to small tanker operations.

Most ocean bulk carriers unable to transit the Seaway are forced to transship their cargoes to lake vessels at lower St. Lawrence ports. Despite additional port costs, this form of operation predominates in the Great Lakes overseas grain trades because it is cheaper than direct shipments via smaller ocean bulk carriers, whose capacities are limited by the Seaway's 25 feet 9 inch draft restriction. Unless there is some modification of the Seaway system's beam and draft dimensions to allow larger ocean bulk carriers to provide lower cost direct services overseas, transshipment of large volumes of export grains in the lower St. Lawrence will continue to be the dominant method of operation.

The effect of the Seaway's beam limitation on accommodation of ocean freighters is marginal. Practically all (98.1 percent) of the conventional breakbulk ships including many converted full and partial containerships have beams less than 76 feet wide. The remainder of the freighter fleet unable to transit the Seaway is composed primarily of newer, larger, high-speed full containerships, not meant for lake use. Some newer breakbulk general cargo vessels are wider than 75 feet, and future designs are expected to feature up to 90-foot beams.

2.8.4 Draft

The Seaway's 25 foot 9 inch draft is a more severe limitation than either the length or beam limits. At the end of 1969 less than half (47.5 percent) of the total world fleet could use the Seaway system fully-loaded. Only 27 percent of the dry bulk carrier and 24 percent of the tanker fleet currently have drafts less than 26 feet. Approximately 58 percent of the total world freighter fleet could transit the Seaway system at full draft in 1970. Containerships generally have fully-loaded drafts ranging from 30 to 35 feet.

Although the Seaway can accommodate more than 16,000 ocean vessels or approximately 85 percent of the total world fleet in length and beam, more than half of these vessels would have to transit the system at less than full load capacity because of the 25 foot 9 inch draft constraint. In fact some 62 percent (182) of the 296 ocean-going vessels currently using the Seaway system forfeit 470,860 deadweight tons of potential carrying capacity (Table C9–13) because of the 25 foot 9 inch draft limitation.

Draft, beam, and length, in that order, are the ship characteristics most seriously limited by the Seaway's existing lock sizes and channel depths. While ship drafts can be adjusted

TABLE C9–13 Total Loss of Potential Carrying Capacity for Existing Ocean-Going Seaway Vessels Due to Draft Limitations

Vessel Type	Total Number	Draft >25'6"	Percent	DWT Loss Total	DWT Loss Average
Bulk Carriers	25	24	96	156,445	6,518
General Cargo	271	158	58	314,415	2,041
Total Fleet	296	182	62	470,860	2,598

SOURCE: Greenwood's Guide to Great Lakes Shipping 1970 Reference 14

to some degree by varying loading, beam and length cannot be, and vessels of excess size are absolutely excluded. Draft restriction affects the carrying capacity of all vessels transiting the Seaway. Because larger tankers and full containerships are not expected to use the Seaway, beam and length constraints pose serious accommodation problems mainly for larger dry bulk carriers. Length and beam restrictions are not currently a serious barrier to traditional breakbulk general cargo vessels.

2.9 Harbors

When a controlling depth of 27 feet was authorized for Great Lakes connecting channels to complement the controlling depth of 27 feet being provided in the St. Lawrence Seaway from Montreal to Lake Erie, the Great Lakes Harbor Study was authorized to determine what improvements would be economically justified to provide commensurate depths at harbors on the Great Lakes. That study recommended improvements at 30 existing harbors and construction of one new harbor. In connection with that study comprehensive overall Great Lakes traffic analyses were made for iron ore, coal, stone, grain, and for overseas general cargo. Commodity receipts, available project depths, and construction costs for Federal and private commercial harbors on the Great Lakes are shown in Tables C9–14 and C9–15. The depths shown are for the harbor areas that control maximum drafts.

2.10 Navigation Program

The Great Lakes navigation program is concerned with improving connecting channels and harbors in order to take advantage of the authorized 27-foot depths now provided in the Great Lakes connecting channels, the Welland Canal, and the St. Lawrence Seaway. The connecting channel improvements authorized in 1956 were approximately 90 percent complete as of 1970. The remaining work primarily concerns channel widening at critical bends. The Great Lakes Harbor study (1966) recommended harbor improvements at 30 harbors. Most of these projects are now complete.

Navigation construction projects are authorized by the Congress of the United States based upon reports submitted by the Corps of Engineers. The major reports submitted and studies now under way by the Corps of Engineers, Department of Transportation, and the Maritime Administration are given in Table C9–16. During the period 1961 to 1970 Federal expenditures by the Corps of Engineers for navigation improvements for the Great Lakes Region have averaged $40 million annually. Construction expenditures, which averaged $30 million annually for the first half of the decade, have declined to approximately $15 million annually. Operation and maintenance costs have increased from $10 million annually for the period 1961 to 1965 to $20 million annually for the period 1966 to 1970 (Subsection 2.11, Navigation System Costs).

2.11 Navigation System Costs

2.11.1 Existing System Costs

The Federal costs of providing and maintaining harbors on the Great Lakes is shown in Table C9–14. The non-Federal share of project costs had reached approximately $30 million through fiscal year 1966. Non-Federal costs for general cargo facilities totaled approximately $80 million and specialized facilities cost $170 million for the 1946 to 1965 period. Costs for locks, channels, and harbors are shown in Table C9–17. (See references 4, 31, 47 and 53.)

A recent survey by the Maritime Administration of port development expenditures indicated the following expenditures for the 1946 to 1970 period: North Atlantic, $454 million; South Atlantic, $122 million; Gulf Coast, $221 million; Pacific Coast, $150 million; Great Lakes, $85 million; Canada, $275 million. A breakdown of the U.S. total transportation bill is presented in Table C9–18.

When the Seaway opened, it was relatively easy to persuade port cities and port districts

(Continued on page 37)

TABLE C9–14 Federal Habors on the Great Lakes

PSA	Harbor	Existing Depth (ft.)	Major Commodities (million tons)		Total Cost ($1,000) as of June 30, 1969			Annual Maintenance	
					Constr.	Rehab.	Maint.	Av.Cu.Yd. Dredged	Av.Maint.Costs 1965-1969
	LAKE SUPERIOR								
1.1	Grand Marais, Minn.	16-20	Logs	(0.04)	$ 451	$ ---	$ 256	2,000	$ ---
	Two Harbors, Minn.	28-30	Iron Ore	(5.33)	3,709	---	370	1,000	5,636
	Duluth-Superior, Minn.-Wis.	23-30	Iron Ore Grain Coal Limestone	34.4 3.6 2.5 1.0 (43.5)	15,741	---	7,578	68,000	220,360
	Ashland, Wis.	20-25	Coal	0.28 (0.35)	1,696	---	863	---	---
1.2	Ontonagon, Mich.	15-17	Coal	0.19 (0.23)	332	---	2,021	30,000	127,934
	Presque Isle, Mich.	28-30	Iron Ore	(6.6)	1,190	---	175	1,000	---
	Marquette, Mich.	27	Coal Iron Ore	0.64 1.26 (1.98)	1,283	---	585	1,000	---
	Keweenaw Waterway, Mich.	25	Coal Iron Ore	.07 .17 (0.33)	5,967	---	4,815	55,000	55,224
	LAKE MICHIGAN								
2.1	Menominee, Mich. & Wis.	15-23	Coal Limestone Pulp	0.13 0.06 0.09 (0.38)	534	1,352	1,111	8,000	15,386
	Green Bay, Wis.	18-26	Coal Limestone Fuel Oil Cement	1.82 0.15 0.21 0.25 (2.8)	4,592	---	2,681	121,000	172,064
	Sturgeon Bay, Wis.	22-23		(0.37)	1,060	885	3,523	50,000	50,726
	Kewaunee, Wis.	20	Lumber Paper	0.14 0.28 (1.35)	752	617	1,251	33,000	39,342
	Two Rivers, Wis.	10-18		(0.12)	360	58	1,643	52,000	56,636
	Manitowoc, Wis.	12-25	Coal Lumber Paper Cement	0.13 0.11 0.43 0.34 (2.36)	875	---	1,493	40,000	36,689
	Sheboygan, Wis.	15-25	Coal	0.25 (0.39)	1,136	609	1,357	20,000	43,217
2.2	Port Washington, Wis.	18-21	Coal	0.72 (0.87)	999	---	393	8,000	9,158
	Milwaukee, Wis.	21-30	Grain Coal Limestone Petro.Prod.	0.62 1.52 0.27 0.96 (6.83)	8,231	1,892	4,936	48,000	90,035
	Racine, Wis.	19-23		(0.12)	1,205	---	1,167	21,500	38,978
	Kenosha, Wis.	21-27		(0.39)	847	788	1,007	25,800	37,899
	Waukegan, Ill.	8-22	Coal Cement	0.11 0.31 (0.57)	823	---	1,919	34,000	40,573
	Chicago, Ill.	21-29		(0.75)	4,789	1,327	3,768	7,900	2,026
	Calumet Harbor, Ind. & Ill. & Lake Calumet	27-29	Grain Iron Ore Iron Pl. Coal Limestone	3.2 9.4 2.2 6.4 2.6 (28.6)	22,072	689	8,080	146,000	377,224

TABLE C9–14 (continued) Federal Harbors on the Great Lakes

PSA	Harbor	Existing Depth (ft.)	Major Commodities (million tons)		Total Cost ($1,000) as of June 30, 1969 Constr.	Rehab.	Maint.	Annual Maintenance Av.Cu.Yd. Dredged	Av.Maint.Costs 1965–1969
	LAKE MICHIGAN (continued)								
2.2	Indiana Harbor, Ind.	22–29	Iron Ore Limestone Petro.Prod.	10.0 1.9 5.7 (18.8)	$ 4,897	$ ---	$ 3,957	200,000	$ 113,174
	Burns Waterway, Ind.	27–30	Iron Ore Limestone	0.65 0.19 (0.88)	13,600	---	100	N/A	N/A
	Michigan City, Ind.	6–18	---	---	1,544	900	2,337	46,000	75,488
2.3	St. Joseph, Mich.	18–21	Limestone	0.29 (0.60)	976	365	2,919	87,000	105,114
	South Haven, Mich.	19–21	---	(0.05)	452	880	1,905	75,000	79,880
	Holland, Mich.	21	Coal Limestone	0.11 0.11 (0.26)	772	502	2,315	100,000	110,721
	Grand Haven, Mich.	21–23	Coal Sand, Gravel	0.10 3.1 (3.70)	1,283	814	6,462	100,000	189,119
2.4	Manistique, Mich.	18–19	---	(0.01)	1,299	316	1,358	10,500	83,150
	Gladstone, Mich.	24		(0.30)	333	---	4	---	---
	Muskegon, Mich.	27–29	Coal Petro.Prod.	1.4 0.9 (3.40)	2,912	743	1,808	70,000	80,717
	White Lake, Mich.	16	Sod. Hyd.	0.004	208		1,082	34,000	37,857
	Ludington, Mich.	18	Coal Limestone	0.18 0.72 (3.66)	1,528	358	3,662	50,000	41,276
	Manistee Harbor, Mich.	23–25	Coal Sand, Gravel	0.25 0.35 (0.70)	2,697	1,374	1,883	48,000	65,567
	Frankfort, Mich.	18–24	Lumber Pulp Paper	0.15 0.11 0.3 (1.61)	1,921	275	1,416	35,000	41,296
	Charlevoix, Mich.	18	Coal	0.11 (0.19)	82	789	629	20,000	15,280
	LAKE HURON								
3.1	Alpena, Mich.	15–21	Coal Cement	0.7 2.3 (3.1)	337	---	259	8,000	12,933
	Cheboygan, Mich.	21		(0.12)	504	---	330	25,000	13,448
3.2	Saginaw, Mich	16.5–27	Grain Coal Limestone	0.13 1.2 2.1 (5.1)	13,134	---	4,378	500,000	248,258
	Harbor Beach, Mich.	21–23	Coal	(0.24)	1,201	195	1,824	273,900	51,806
	LAKE ERIE								
4.1	Port of Detroit	27–29.5	Iron Ore Iron Pl. Coal Limestone Cement	9.8 1.3 9.2 5.8 0.9 (30.1)	76,595	---	6,366	550,000	571,369
	St. Clair River		Coal	4.9 (6.1)	---	---	---	---	---
	Detroit River[a]								
	Rouge River[a]	17–25			675	---	4,792	---	347,243
	Trenton Channel[a]								
	Monroe, Mich.	21	Coal	0.06 (0.07)	987	---	2,489	200,000	100,336

TABLE C9-14 (continued) Federal Harbors on the Great Lakes

PSA	Harbor	Existing Depth (ft.)	Major Commodities (million tons)		Total Cost ($1,000) as of June 30, 1969 Constr.	Rehab.	Maint.	Annual Maintenance Av.Cu.Yd. Dredged	Av.Maint.Costs 1965-1969
	LAKE ERIE (continued)								
4.2	Toledo, Ohio	18-28	Iron Ore Grain Coal	5.6 2.3 20.7 (31.1)	$ 17,192	$ ---	$ 13,113	100,000	$ 718,115
	Sandusky, Ohio	21-26	Coal	6.8 (6.9)	6,727	676	3,953	600,000	285,139
	Huron, Ohio	25	Iron Ore Limestone	2.9 0.4 (3.3)	1,304	247	2,100	200,000	81,337
4.3	Lorain, Ohio	17-29	Iron Ore Coal Limestone	4.4 3.3 0.7 (9.1)	13,310	---	3,907	240,000	181,111
	Cleveland, Ohio	23-29	Iron Ore Sand, Gravel Limestone	17.6 1.9 2.6 (24.6)	31,400	465	30,466	900,000	1,913,003
	Fairport, Ohio	8-25	Limestone	2.1 (2.6)	2,960	---	4,398	400,000	206,552
	Ashtabula, Ohio	16-29	Iron Ore Coal Limestone	6.2 3.4 0.8 (10.8)	11,680	---	3,150	180,000	149,159
	Conneaut, Ohio	8-28	Iron Ore Coal Limestone	6.5 6.4 1.0 (13.9)	8,347	652	2,576	80,000	40,869
	Erie, Pa.	18-29	Limestone Sand, Gravel	0.37 0.37 (1.1)	3,598	1	4,799	295,000	95,713
4.4	Port of Buffalo, N.Y.	22-30	Grain Iron Ore Limestone Coal	1.7 8.7 2.3 0.6 (16.0)	23,115	295	14,367	600,000	710,784
	LAKE ONTARIO								
5.1	Rochester, N.Y.	21-24	Coal	0.4 (0.6)	2,439	---	4,168	360,000	128,730
5.2	Great Sodus Bay, N.Y.	20-22	(No commerce)		611	714	1,461	5,000	38,292
	Oswego, N.Y.	21-27	Cement	0.2 (0.4)	8,430	308	2,653	80,000	56,714
5.3	Ogdensburg, N.Y.	19-21		(0.3)	646	---	730	5,000	14,447
	Totals			305.0	$338,704	$19,086	$195,104	7,250,600	$3,355,560

[a]Included in Port of Detroit.

TABLE C9-15 Private Harbors on the Great Lakes

Planning Subarea	Harbor	Existing Depth (ft.)	Major Commodities (million tons)	
	LAKE SUPERIOR			
1.1	Taconite, Minn.	27	Iron Ore	11.3
				(11.9)
	Silver Bay, Minn.	27	Iron Ore	11.9
				(12.1)
	LAKE MICHIGAN			
2.2	Oak Creek, Wis.	20	Coal	(1.4)
	Buffington, Ind.	26	Limestone	1.72
			Cement	0.36
				(2.3)
	Gary, Ind.	27	Iron Ore	9.1
			Limestone	1.9
				(11.5)
2.4	Port Dolomite, Mich.	29	Limestone	(3.6)
	Port Inland, Mich.	--	Limestone	(4.2)
	Escanaba, Mich.	27	Coal	0.3
			Iron Ore	7.2
				(8.2)
	Petoskey Penn Dixie Harbor, Mich.	--	Coal	0.14
			Cement	0.35
				(0.5)
	LAKE HURON			
3.1	Calcite, Mich.	25	Limestone	(13.3)
	Stoneport, Mich.	25	Limestone	(6.4)
	Port Gypsum, Mich.	--	Gypsum	(0.3)
	Alabaster, Mich.	--	Gypsum	(0.5)
	Drummond Island, Mich.	23	Limestone	(2.6)
	LAKE ERIE			
4.2	Marblehead, Ohio	--	Limestone	(2.5)

Commodity[a]	Federal	Private	Total
Iron Ore	129.5	39.5	169.0
Coal	74.8	1.8	76.6
Limestone	23.0	36.2	59.2
Grain	11.6	--	11.6
Total	238.9	77.6	316.5
Other traffic[b]	66.1	3.9	70.0
Combined Total	305.0	81.5	386.5

[a]Includes both receipts and shipments.

[b]Comprised approximately 18% of total U.S. receipts and shipments in 1969.

TABLE C9-16 Prior and Ongoing Navigation Studies

Study, Status, and Cost	Authorization	Purpose	Recommendation
CORPS OF ENGINEERS Major Completed Studies			
St. Lawrence Seaway (Development of the Great Lakes-St. Lawrence Basin) Status: 27-foot seaway was open to navigation in 1959.	Act of May 13, 1954 (Public Law 358 83rd Congress)	To open the Great Lakes to ocean navigation and create 2,200,000 hydro-electric horse-power to be commonly shared between the United States and Canada.	Authorized by 1954 Wiley-Dondero Act (Public Law 358, 83rd Congress, as amended).
Connecting Channels of the Great Lakes Status: 27-foot channel available since 1962. Widening at bends and compensating works not complete. Cost: $110,327,000	Senate Public Works Committee resolution dated 3-25-53 and House Public Works Committee dated 6-24-53.	To determine an up-to-date estimate of the costs for accommodation of present and prospective commerce, including considera-tion of a 27-foot channel.	That the existing project be modified to provide for (1) deepening and improving the channel in St. Marys River, Straits of Mackinac, St. Clair River, Lake St. Clair and Detroit River; (2) an alter-nate plan authorizing construction of cutoff channel in Canada at Southeast Bend, St. Clair River in lieu of further improvement of existing channel in this reach.
Great Lakes Harbors Status: Almost all harbor improvements have been completed. Cost: $ 7,965,200 4,514,800 $12,480,000	Senate Public Works Committee Resolution dated 5-18-56 and House Public Works Committee Resolution dated 6-27-56.	To determine advisability of further improvement of harbors on the Great Lakes in the interest of present and prospective deep-draft commerce to take advantage of 27-foot depths in Connecting Channels and Seaway.	Improvements authorized at 30 harbors from approximately 40 reports plus 7 additional harbors after report submittal.
CORPS OF ENGINEERS Studies under way.			
Water Levels on the Great Lakes Status: Completed in 1965 to present plans and to summarize other data to facilitate the inter-national study below. Cost: $916,500	House Public Works Committee Resolution dated 6-26-52.	To study the damage resulting from changes in levels of the Great Lakes and the feasibility of measures to reduce that damage.	
Water Levels on the Great Lakes Status: International Joint Commission Study under way with scheduled completion date of 1974. Cost: $1,900,000 (U.S. only)	International Joint Commission dated 10-7-64.	A coordinated study between Canada and the United States for further regulation of the water levels of the Great Lakes (under auspices of International Joint Committee, IJC).	
Great Lakes--St. Lawrence Seaway Navigation Season Extension Status: Full survey scope study is authorized, under way, and scheduled for completion by 1975. The demonstration program, also under way, is scheduled for completion in 1974. Interim progress reports will be submitted annually. Cost: $9,500,000 ($6,500,000 for demonstration program, $3,000,000 for studies and report).	Section 304 of the River and Harbor Act (Title III, Public Law 89-298) dated 10-27-65.	To determine the engineering and economic feasibility of extending the navigation season on the Great Lakes-St. Lawrence System to include part or all of the winter season during which navigation is now precluded by ice.	The feasibility study recommended the following: (1) A full survey scope, under auspices of the International Joint Commission, to define cost, economic justification, and degree of Federal interest; (2) Feasible winter navigation features be incorporated into design of all future modifications of Federal navigation facilities, in-cluding the Great Lakes Connecting Channels, locks and harbors, and placement of suitable dredged material into ice-stabilizing islands where appropriate; (3) An operations center be established for collecting, process-ing, and disseminating information, in-cluding weather and ice data vital to the maximum use of the present system.
Great Lakes Connecting Channels and Harbors Status: The main thrust of the study is evalua-tion of environmental, engineering feasibility, and economic effects of alternatives. Completion is scheduled for 1974-75. Cost: $1,000,000	Senate Public Works Committee Resolution dated 6-2-69.	To provide for ease of navigation and the safe passage of larger size vessels being built to the dimensions of the New Poe Lock. Solutions must consider not only commercial benefits but also effects of any improve-ments on the environment. Consideration will be given also to the problem of shore erosion.	
St. Lawrence Seaway Additional Locks Status: Geophysical, economic, and capacity studies are under way. Scheduled for completion in 1975.	Senate Public Works Committee Resolution dated 6-15-66.	To consider the need for new larger locks parallel to the existing locks to accommo-date projected increases in traffic which may exceed the capacity of the existing locks.	
Lake Erie-Lake Ontario Waterway (LELO) Status: Completed in 1974. Cost: $2,500,000	Senate Public Works Committee Resolution dated 5-6-58 and House Public Works Committee Resolution dated 7-16-58.	Increasing traffic may reach the practical capacity of the Welland Canal in the fore-seeable future. The LELO study considers the engineering and economic feasibility of constructing a canal in the United States to provide facilities necessary for the anticipated increases in U.S. waterborne traffic only.	An international study (Canada-United States) should be undertaken immediately to consider the needs of both Canadian and United States traffic over the entire Great Lakes-St. Lawrence System.

TABLE C9-16 (continued) Prior and Ongoing Navigation Studies

Study, Status, and Cost	Authorization	Purpose	Recommendation
Domestic and International Transportation of U.S. Foreign Trade: 1970. Status: Completed.	Sponsored jointly by Corps of Engineers and Department of Transportation under agreement with Bureau of Census, Department of Commerce.	To determine the foreign trade commodity movements or flows within the United States during 1970 (flows prior to shipment via the U.S. port of export or after receipt at the U.S. port of entry) which cannot be obtained directly from public records. Such data were obtained for 1956 foreign trade flows from an origin-destination study on a sample basis by the Bureau of Census under contract with the Corps of Engineers. This study will develop similar information regarding liner-type general cargo commodities moving in waterborne and airborne U.S. foreign trade (e.g., degree of containerization for the domestic and international segments of the commodity movements; the major mode of domestic transport between United States inland points and ports of entry or exit).	
DEPARTMENT OF TRANSPORTATION			
The Effects of Inland Freight Rates and Services on the St. Lawrence Seaway, DOT-OS-10019. Status: Completed April 1972.		This research study, funded and administered by DOT, is a research program designed as an examination of the relevant principles of competitive rate making in the Interstate Commerce Act. The study analyzes these principles as established by Commission decisions by their specific application to selected rates from the Seaway region's inland tariff structure. The study examines the selected rates, giving consideration to current Commission procedures but also to new approaches for testing established principles and precedents of the Interstate Commerce Act. In essence, the study is intended to generate a set of conclusions as to whether the existing inland rate structure is unreasonable, discriminatory, or unduly prejudicial to the Seaway.	
DEPARTMENT OF TRANSPORTATION			
An Economic Feasibility Study of Alternative Waterborne Cargo Feeder Systems for the Great Lakes-St. Lawrence Seaway Status: Completed April 1972.		This is a study jointly funded by the Department of Transportation and the St. Lawrence Seaway Development Corporation. Its purpose is to determine the feasibility, design, and implementation of a feeder system operating within the Lakes primarily serving unitized cargo (containers and pallets). The study is being conducted in two phases with the second phase being implemented in late May 1971 for an expected 8-month duration before the final report is submitted. Phase II concentrates on close examination of alternate feeder systems to determine operational cost, competitive position, market potential, and to select and recommend the necessary process for implementation of whichever system is determined most feasible. Design and operation of the feeder system will consider seasonal operation and physical characteristics of the Seaway as they currently exist.	
MARITIME ADMINISTRATION			
Offshore Terminals Study Status: Under way. Cost: $200,000		The study is designed to help pave the way for the introduction of "supersized" bulk carriers. The study examines the economics inherent in using these vessels in the U.S. foreign trade. Phase I: Project bulk-cargo shipment requirements for U.S. industry over the next 30 years on a geographic basis and assess the capability of present bulk-cargo distribution systems to handle them. Compare alternate methods of using "supersized" ships to carry these cargoes, including using feeder vessels and pipelines; moving user industries to sites where these ships can berth; and formulating concepts in design, construction, and operation of offshore island terminals, including development of economic and technical data. Phase II: Specific privately sponsored development studies, conducted jointly with Federal and State agencies, to define contract specifications, necessary legislative proposals, and operating agreements among proposed users. Phase III: The final part will be construction and testing of one prototype offshore terminal.	
INTERSTATE COMMERCE COMMISSION (ICC)			
Rail Freight Rate Study Status: Decision expected in 1974.		Study and litigation to determine whether rail rates to and from the Great Lakes have become distorted in relationship to corresponding rates to and from other ports in the Atlantic and Gulf Coast areas.	

TABLE C9-17 Federal Cost for Great Lakes-St. Lawrence Seaway System (Millions of Dollars)

	Construction	All Other Costs	Average Annual Cost Operation and Maintenance 1967-1970
Locks and Channels			
St. Marys River[a]	150.4	66.0	3.0
St. Clair River[a]	19.2	3.9	0.34
Channels in Lake St. Clair[a]	7.7	2.2	0.14
Detroit River[a]	76.6	7.0	0.65
St. Lawrence Seaway			
Welland Canal (Canadian)[b]	280.0	--	--[i]
Canadian Section[b]	349.0[e]	--	59.1[i]
United States Section[c]	125.4	32.6[h]	2.5
Seaway Total	754.4	32.6	61.6
St. Lawrence River (Canadian)[b]	238.0[e]	--	51.8
Non-toll canals (Canadian)[b]	39.0[e]	--	--
Superseded canals (Canadian)[b]	50.0[e]	--	--
Canadian Subtotal	956.0	--	110.9
United States Subtotal	379.3	111.7	6.6
Harbors			
Great Lakes			
United States[a]	290.8[f]	261.9[f]	11.3[f]
Canadian[b]	142.0[e]	--	--
Great Lakes Total	432.8	261.9	11.3
St. Lawrence River (Canadian)[b]	322.0[e]	--	--
Marine Services			
Canadian Section[b]	353.0[g]	--	--
United States Section[d]	280.0	--	--
Canadian Total	1,783.0	--	110.9
United States Total	950.1	373.6	17.9
Combined Total	2,733.1	373.6	128.8

[a]Source: 1970 Annual Report of the Chief of Engineers, Corps of Engineers, Department of the Army. (Cost to June 30, 1970)[46]

[b]Source: The Seaway in Canadian Transportation, D. W. Carr & Associates, for the St. Lawrence Seaway Authority, October 1970. (Costs to 1968 or 1969)[4]

[c]Source: St. Lawrence Seaway Development Corporation. (Annual Reports 1959-1971)[33]

[d]Source: Harbor and Port Development, Corps of Engineers, Washington, D.C., 1968. (Costs to 1966)[47]

[e]Total investment includes all costs (construction, operation and maintenance, rehabilitation, etc.)

[f]Includes about $21 million, $20 million, and $1 million (construction, all other and average annual maintenance cost respectively) for harbors containing only recreational boats.

[g]Comprises cost of aids to navigation, icebreakers, pilotage, etc.

[h]Includes $8.4 million for major structure repairs.

[i]Includes Welland Canal.

TABLE C9-18 The Nation's Freight Bill (Millions of Dollars)

	1958	1960	1965
Highway			
Truck - Intercity			
ICC Regulated	6,081	7,155	10,015
Non-ICC Regulated	10,834	10,744	15,872
Truck - Local	12,643	14,289	21,836
Bus	31	42	71
Total	29,489	32,230	47,794
Rail			
Railroads	8,748	8,739	9,695
Water			
International	1,513	1,765	2,509
Coastal, Intercoastal and Non-Contiguous	724	747	692
Inland Waterways	292	312	374
Great Lakes	174	227	210
Total	2,703	3,051	3,785
Oil Pipe Line			
ICC Regulated	721	770	904
Non-ICC Regulated	117	125	157
Total	838	895	1,061
Air			
Domestic	137	175	322
International	91	114	234
All-Cargo & Supplemental	71	71	144
Total	299	360	700
Other Carriers			
Freight Forwarder	416	438	461
REA Express	352	345	397
Total	768	783	858
Other Shipping Costs			
Loading and Unloading Freight Cars	1,062	1,097	1,106
Operation of Traffic Departments	223	241	293
Total	1,285	1,338	1,399
Grand Total	44,130	47,396	65,292
Gross National Product (Billions of Dollars)	447.3	503.7	681.2
Grand Total % of GNP	9.87	9.41	9.58

Source: Journal of Commerce 12 Aug 68.

to lay out millions of dollars for port expansion. Today cities are faced with critical social and financial problems, and are struggling with costly programs of urban renewal, redevelopment, and public relief. In these circumstances further expansion of public ports may have a low priority, while resources flow to areas of political sensitivity, rather than toward a proprietary venture. Many cities are approaching the limit of their bonded indebtedness. If they turn to revenue bonds, high interest rates will put a heavy burden on capital expansion.

For these reasons the already low level of port investment in the Great Lakes has been decreasing in recent years. If the decline in public investment is only temporary, the full potential of the Great Lakes may yet be realized.

Table C9–19 shows the relationships of Federal first cost, maintenance cost, and total cost to tonnage handled at 15 major Federal Great Lakes harbors. Although these figures do not include the more than $280 million in non-Federal funds for docks and facilities, they do indicate the varying cost of providing for handling cargo at major ports. For example, Cleveland Harbor costs to date are $62.3 million. Its 1970 commerce was 24.6 million tons. Cleveland is the most expensive lake harbor to maintain ($1.9 million annually). Duluth-Superior Harbor, which handled more cargo (43.5 million tons) in 1969, had total costs of only $23.3 million and maintenance costs of $0.22 million annually. These cost figures indicate the value of regional port development in minimizing costs and maximizing benefits.

2.11.2 Costs to Increase System Capacity

The costs of increasing the system capacity were estimated in 1968[49] for three situations: (1) increasing the capacity of the system

TABLE C9–19 Fifteen Federal Great Lakes Harbors in Order of Decreasing Construction, Maintenance, and Total Costs (Thousands of Dollars)

Construction				Maintenance			Total Federal Cost		
Rank	Harbor	1969 Total Commerce[a]	Cost[b]	Rank	Harbor	Cost[c]	Rank	Harbor	Cost[d]
1	Detroit River[e]	122.9[f]	79,400	1	Cleveland	1,913	1	Detroit River[e]	88,400
2	Cleveland	24.6	31,400	2	Detroit River[e]	918	2	Cleveland	62,300
3	Buffalo	14.1	23,100	3	Toledo	718	3	Buffalo	37,800
4	Calumet	27.5	22,100	4	Buffalo	711	4	Calumet	30,900
5	Toledo	31.1	17,200	5	Calumet	377	5	Toledo	30,300
6	Duluth-Superior	43.5	15,700	6	Sandusky	285	6	Duluth-Superior	23,300
7	Lorain	9.1	13,300	7	Saginaw River	248	7	Saginaw River	17,500
8	Saginaw River	5.1	13,100	8	Duluth-Superior	220	8	Lorain	17,200
9	Ashtabula	10.8	11,700	9	Fairport	206	9	Milwaukee	15,100
10	Oswego	0.4	8,400	10	Grand Haven	189	10	Ashtabula	14,800
11	Conneaut	13.9	8,300	11	Lorain	181	11	Conneaut	11,500
12	Milwaukee	6.8	8,200	12	Green Bay	172	12	Oswego	11,400
13	Sandusky	6.9	6,700	13	Ashtabula	149	13	Sandusky	11,300
14	Indiana	18.8	4,900	14	Indiana	137	14	Indiana	8,900
15	Green Bay	2.8	4,600	15	Rochester	129	15	Grand Haven	8,600
	Fairport[g]	2.6	2,600		Milwaukee[g]	90		Fairport[g]	7,400
	Rochester[g]	0.6	2,400		Oswego[g]	57		Green Bay[g]	7,300
	Grand Haven[g]	3.7	1,000		Conneaut[g]	41		Rochester[g]	6,600

[a] Millions of tons

[b] Cumulative construction cost (Federal only) through June 30, 1969.

[c] Cumulative Federal maintenance cost through June 30, 1969.

[d] Construction, maintenance, and rehabilitation through June 30, 1969 (Federal costs only).

[e] Includes Port of Detroit and Rouge River.

[f] Comprises 30.2 million tons traffic at Port of Detroit and 92.7 million tons through traffic.

[g] Not ranked.

with no increase in season length (Table C9–20)

(2) extending the length of season by two, four, or six weeks (Table C9–21)

(3) a combination of increased capacity system and extended season (Table C9–22)

Costs of locks, dredging, and harbor structures are presented in Tables C9–23, C9–24, and C9–25. Only nineteen harbors, Thunder Bay, Silver Bay, Taconite, Duluth, Marquette, Escanaba, Milwaukee, Chicago Harbor, Calumet Harbor, Indiana Harbor, Detroit, Toledo, Sandusky, Lorain, Cleveland, Hamilton, Toronto, Buffalo, and Conneaut, were selected for cost analysis. The 31-, 32-, and 34-foot deep systems were designed to handle vessels of the following length, beam, and draft: 1,000 by 105 by 29 feet; 1,200 by 115 by 30 feet; 1,400 by 125 by 32 feet. The first cost of increasing to a 31-foot deep system is $3.5 billion. It would cost $4 billion for a 32-foot system and $5.3 billion for a 34-foot system. The cost of deepening the harbors and channels above the Welland Canal for each system alone would be $1.2, $1.4 and $2.2 billion. Of that, 91 percent, 92 percent, and 95 percent would be for dredging in channels and harbors.

A Department of Transportation study considered two-, four-, and six-week season extensions costing $246 million, $299 million, and $358 million. The cost of extending the season and increasing the system capacity (Table C9-22) is less than the cost of accomplishing each separately.

2.11.3 Vessel Cost

The actual cost of operating the vessels required to transport 1995 commerce has been estimated for the Great Lakes Water Levels Study, sponsored by the International Joint Commission. A summary is shown in Table C9–26. Details are presented in Bureau of Mines Circular 8461[1] and in the Navigation Appendix to the Water Levels Study.[20] The capital cost of a new bulk vessel for Great Lakes use (delivered in 1972) is estimated at

TABLE C9–20 Cost of Increased Capacity System (1968 Costs in Millions of Dollars)

	Criteria								
Ship size, ft.	1000 x 105 x 29			1200 x 115 x 30			1400 x 125 x 32		
Lock size, ft.	1200 x 110 x 32			1400 x 125 x 34			1600 x 140 x 36		
Channel depth, ft.	31			32			34		
Channel width, ft.	600			700			800		
Reach	First Cost	Interest During Const.[a]	Total	First Cost	Interest During Const.[a]	Total	First Cost	Interest During Const.[a]	Total
Great Lakes above Welland Canal									
Locks									
Sault Ste. Marie	40	6	46	42	6	48	44	7	51
St. Clair River Dam & Lock	50	7	57	52	7	59	54	8	62
Dredging in Channels	615	92	707	735	111	846	1,310	197	1,507
Dredging in Harbors	274	41	315	332	50	382	450	68	518
Harbor Structures Affected by Dredging	42	7	49	46	7	53	49	7	56
Subtotal	1,021	153	1,174	1,207	181	1,388	1,908	287	2,194
		1.2 Billion[b]			1.4 Billion[b]			2.2 Billion[b]	
Welland Canal and L. Ontario									
Welland (All American) Canal	1,224	184	1,408	1,343	201	1,544	1,414	212	1,626
Lake Ontario Port Structures	8	1	9	10	1	11	11	1	12
Lake Ontario Harbor Dredging	5	1	6	6	1	7	10	1	11
Subtotal	1,237	186	1,423	1,359	203	1,562	1,435	214	1,649
		1.4 Billion[b]			1.6 Billion[b]			1.7 Billion[b]	
St. Lawrence Seaway									
Locks	386	58	444	403	61	464	423	64	487
Channel Dredging	402	60	462	476	71	547	816	122	938
Subtotal	788	118	906	879	132	1,011	1,239	186	1,425
		0.9 Billion[b]			1.0 Billion[b]			1.4 Billion[b]	
Total System Cost	3,046	457	3,503	3,445	516	3,961	4,581	687	5,268
		3.5 Billion[b]			4.0 Billion[b]			5.3 Billion[b]	

Data Source: DOT - St. Lawrence Seaway Task Force, Report of the Technical Subgroup, prepared by U. S. Coast Guard (November 1968).

[a]6% x 1/2 of 5-year construction period.

[b]Totals are rounded figures.

approximately $12 to $15 million for a vessel 500 to 730 feet long, and $20 to $24 million for a vessel 900 to 1,000 feet long. Hourly operating costs (1971) range from $271 for a class 4 (500 feet to 550 feet long) to $345 for a class 7 (700 feet to 730 feet long). A class 10 (1,000 feet long) vessel costs $563 per hour. In 1974 the capital cost of a 1,000 feet long vessel to be delivered in 1976 and 1977 was estimated at $35 million.

TABLE C9–21 Estimated Construction Costs to Extend Season of Existing Navigation System (Millions of Dollars)

Season Extension	Present System	Enlarged System: 1000' Ships 31'	Enlarged System: 1200' Ships 32'	Enlarged System: 1400' Ships 34'
2 Weeks	246	295	312	327
4 Weeks	299	358	380	398
6 Weeks	358	430	455	476

TABLE C9–22 Estimated Construction Costs of Extended Season with Increased Capacity (Millions of Dollars)

Season Extension		Channel Depth 31'	Channel Depth 32'	Channel Depth 34'
2 Weeks	Lakes, Channels, Locks & Canals	3,129	3,514	4,677
Dec. 15 to 29	Ports & Harbors	380	454	598
	Total	3,509	3,968	5,274
4 Weeks				
Dec. 15 to	Lakes, Channels, Locks & Canals	3,161	3,546	4,709
Jan. 12	Ports & Harbors	380	454	598
	Total	3,541	4,000	5,307
6 Weeks	Lakes, Channels, Locks & Canals	3,418	3,845	5,041
Dec. 15 to	Ports & Harbors	380	454	598
Jan. 26	Total	3,798	4,299	5,639

Reference 49, pages 220 and 235. The difference in costs on pages 220 and 235 of reference 49 is added to the cost of increasing system capacity (Table C9-20) to obtain the above costs.

TABLE C9–23 Cost of Adding Locks to Increase Capacity of Existing System (Millions of Dollars)

	Ship Size: 1000 x 105 x 29	Ship Size: 1200 x 115 x 30	Ship Size: 1400 x 125 x 32
Lock	Lock Size: 1200 x 110 x 33	Lock Size: 1400 x 125 x 34	Lock Size: 1600 x 140 x 36
St. Lambert	50.0	52.0	54.0
Cote. St. Catherine	61.0	63.0	66.0
Lower Beauharnois	57.0	60.0	64.0
Upper Beauharnois	60.0	62.0	65.0
Snell	64.0	67.0	70.0
Eisenhower	76.0	79.0	82.0
All American Canal (Welland Reach)	416.0	482.0	530.0
Iroquois (includes canals)	66.0	70.0	75.0
Sault Ste. Marie	40.0	42.0	44.0
St. Clair River Lock	18.0	20.0	22.0
St. Clair River Dam	32.0	32.0	32.0
Total	940.0	1,029.0	1,104.0
Interest during construction (except All American Canal)[a]	76.0	82.0	86.0
Total Costs and Interest	1,016.0	1,111.0	1,190.0

[a]Interest during construction and all engineering costs are already included in All American Canal.

TABLE C9–24 Estimate of Dredging Required to Increase the System Capacity[a]

Item		System Depth 31' million cu. yds.	31' million dollars	32' million cu. yds.	32' million dollars	34' million cu. yds.	34' million dollars
St. Lawrence Seaway		130.0	412.0	156.0	494.0	280.0	882.0
Iroquois Canal		8.7	50.0	9.1	53.0	9.8	56.0
Welland Canal (LELO)		220.0	534.0	190.0	579.0	200.0	607.0
Sub-Total		358.7	996.0	355.1	1,126.0	489.8	1,545.0
Interlake Connections		223.0	707.0	267.0	846.0	476.0	1,507.0
Planning Subareas	Harbors						
1.1	Silver Bay (rock)	0.01	0.2	0.02	0.4	0.04	0.7
1.1	Taconite Harbor	NA	0.6	NA	1.1	NA	2.0
1.1	Duluth	5.0	17.0	6.7	22.0	10.0	33.0
1.2	Marquette	0.1	0.2	0.1	0.2	0.1	0.3
2.2	Milwaukee	7.6	25.1	9.2	31.0	12.3	41.0
2.2	Calumet	NA	53.0	NA	66.0	NA	92.0
2.2	Chicago	0.1	0.6	0.15	0.5	0.2	0.8
2.2	Indiana Harbor	NA	11.2	NA	14.0	NA	20.0
2.2	Port of Indiana	NA	6.0	NA	7.0	NA	8.0
2.4	Escanaba	0.2	0.6	0.2	0.8	0.4	1.2
4.1	Detroit	NA	11.4	NA	14.0	NA	19.0
4.2	Toledo	NA	38.0	NA	47.0	NA	66.0
4.2	Sandusky	4.5	15.0	5.7	19.0	7.9	26.1
4.3	Lorain	0.7	5.3	0.9	7.1	1.3	11.0
4.3	Cleveland	1.8	6.0	2.2	7.2	3.1	10.2
4.3	Conneaut	0.1	0.4	0.1	0.5	0.2	0.7
4.4	Buffalo	0.8	13.0	1.1	15.2	1.8	24.0
Can.	Thunder Bay	34.1	112.0	39.2	129.0	49.0	162.0
Can.	Hamilton	--	0.2	--	0.3	0.01	0.7
Can.	Toronto	1.7	5.7	2.2	7.1	3.0	10.0
Total, Harbors		56.71	321.5	67.77	389.4	45.25	528.7
Grand Total		638.41	2,024.5	689.87	2,361.4	1,011.05	3,580.7

[a]Includes 6% interest during construction.

TABLE C9–25 Effects of Dredging on Port Structures

Planning Subarea	Harbor	Work Proposed	Channel Depth 31'	32'	34'
1.1	Silver Bay	None	---	---	---
1.1	Taconite	None	---	---	---
1.1	Duluth	None	---	---	---
1.2	Marquette	None	---	---	---
2.2	Calumet	Additional cost to proposed docks in Lake Calumet	$ 2,178,000	$ 2,723,000	$ 3,812,000
2.2	Chicago	Rebuild bulkhead, Navy pier	238,000	297,000	416,000
2.2	Milwaukee	Increased cost to proposed marginal wharf	528,000	660,000	924,000
		Modify existing docks	28,644,000	28,710,000	28,776,000
2.2	Indiana Harbor (Gary)	None	---	---	---
2.4	Escanaba	None	---	---	---
4.1	Detroit	Rebuild private dock frontage	4,019,000	4,307,000	4,594,000
4.2	Toledo	Rebuild private dock frontage	4,468,000	6,930,000	7,392,000
4.2	Sandusky	None	---	---	---
4.3	Lorain	None	---	---	---
4.3	Cleveland	None	---	---	---
4.3	Conneaut	Rebuild bulkhead	739,000	792,000	845,000
4.4	Buffalo	Rebuild bulkhead, Seaway dock	1,525,000	1,634,000	1,742,000
Canada	Thunder Bay	None	---	---	---
Canada	Hamilton	Rebuild bulkhead	2,772,000	2,970,000	3,168,000
Canada	Toronto	Rebuild bridge & bulkhead	6,006,000	8,415,000	8,856,000
		Total	$51,117,000	$57,438,000	$60,525,000
		Construction & Engineering	44,533,000	50,040,000	52,730,000
		Interest during construction	6,584,000	7,398,000	7,795,000

TABLE C9–26 Cost of Transporting Commerce on the Great Lakes (Millions of Dollars)[a]

Commodity	Fleet U.S.	Canadian	Combined	Tons Transported (millions)	Average Cost Per Ton
1970[b]					
Iron Ore	157	36	193	94.2	2.05
Coal	27	15	42	49.3	0.85
Limestone	30	3	33	36.1	0.91
Grain	11	59	70	21.7	0.32
Total	225	113	338	201.3	1.68
1995					
Iron Ore	157	56	213	153.7	1.39
Coal	39	14	53	74.0	0.72
Limestone	34	6	40	63.3	0.63
Grain	7	73	80	30.7	0.26
Total	236	150	386	321.7	1.20

[a]Ref. Water Levels of the Great Lakes, International Joint Commission Special Study Effect of Lake Level Regulation, Navigation Appendix (1971 vessel operating costs are used)

[b]Based on existing conditions.

Section 3

EXISTING AND PROJECTED WATERBORNE COMMERCE

3.1 Existing Waterborne Commerce

3.1.1 General

Concentrations of industry and population in both the United States and Canada, linked with strategically located natural resources and productive agricultural land, produce the Great Lakes traffic. Fifty percent of the steel-producing capacity of the United States is located at Great Lakes ports, and an additional 15 to 20 percent is served by Great Lakes ports. Canadian steel production capacity is even more concentrated at Great Lakes ports. Canadian lake ports represent 82 percent of the nation's capacity. Five of the ten largest United States cities are Great Lakes ports. Canada's largest city, Montreal, is at the entrance to the St. Lawrence Seaway, and Canada's second largest city, Toronto, is a Great Lakes port.

United States Great Lakes traffic is dominated by bulk commodities. They were reported in 1970 in millions of net tons: iron ore, 94; coal, 49; limestone, 36; and grain, 22. Table C9–27 illustrates the growth of major bulk mineral commodities on the Great Lakes. Overseas general cargo, a high-value commodity, accounted for eight million tons of United States traffic in 1969 and seven million tons in 1970.

A summary of the total United States traffic on the Great Lakes and connecting channels for the period 1959 to 1970 is given in Table C9–28.

Great Lakes deep-draft commercial harbors are indicated on Figure C9–2. References 10 and 56 give further information.

3.1.2 Iron Ore

More iron ore is handled at lake ports and along the Seaway than other commodities. The ore moves in both directions on the Seaway system, downbound from Lake Superior and upbound from the lower St. Lawrence River. Both of these movements converge on Lakes Ontario and Erie and at the south end of Lake Michigan.[53]

The greater downbound volume originates on the shores of Lake Superior in the States of Minnesota, Wisconsin, and Michigan, and at the Canadian port of Thunder Bay. The mines of the Mesabi Range provide most of this ore. In 1970 Duluth-Superior, the twin ports that function as the primary outlet for the Mesabi Range, handled 32.4 million tons of iron ore. United States shipments of taconite pellets, the development of which rejuvenated mines on the Mesabi Range, have risen from 17.5 million tons in 1962 to 45.7 million tons in 1970, or from 26.5 percent of total U.S. Great Lakes ore shipments in 1962 to 66.1 percent in 1970.[21] A taconite plant is shown in Figure C9–7. The growth of Great Lakes shipments of iron ore and iron ore pellets is shown in Tables C9–29, C9–30, and C9–31.[21] With the exception of one port, all upper lake loading ports participated in the pellet trade.

The majority of the iron ore originating in the Lake Superior region passes down through Lake Huron and the St. Clair River to steel production plants on Lake Erie. Most of the remainder is transported down to steel furnaces at the south end of Lake Michigan. Small amounts go to Lake Ontario.

Three ports on the north side of the Gulf of St. Lawrence, Sept Iles, Pointe Noire, and Port Cartier, are the leading ports for iron ore from the Quebec-Labrador mines. Tonnages and facilities at major U.S. and Canadian iron ore ports are shown in Table C9–32.

The efficient transfer of iron ore from the originating mine to the processing mill depends on a highly coordinated transportation sequence. This system is comprised of ships, railroads, and dock transfer equipment. The sequence involves moving the iron ore via rail from the mine site to a specialized port facility where the ore is transferred to dry bulk carriers, which carry it to the receiving port.[53]

There are basically two types of facilities used in transferring ore from rail to lake vessels. The traditional port facility, as

TABLE C9–27 Tonnage Handled in Bulk Freight Vessels on the Great Lakes, 1929 to 1970 (Net Short Tons)[a]

Year	(Cargo only) Bituminous Coal[b]	Anthracite Coal[b]	Ore Gross Tons	Ore Net Tons	Stone	Grain	Total
1970	49,529,708	154,002	87,018,233[c]	97,550,021	38,477,439	23,820,347	209,531,517
1969	46,718,540	205,907	86,307,605	96,664,509	36,083,477	16,594,713	196,267,146
1968	48,657,184	204,682	83,631,049	93,666,775	33,093,501	16,325,298	191,947,440
1967	52,683,693	206,975	80,605,929	90,278,641	31,716,614	17,616,863	192,502,786
1966	55,375,935	209,529	85,273,676	95,506,517	34,021,957	25,013,943	210,127,881
1965	54,347,810	225,366	78,627,591	88,062,902	30,819,351	21,875,439	195,330,868
1964	51,921,001	221,741	78,115,327	87,489,166	30,771,477	21,637,255	192,040,640
1963	51,426,707	216,089	67,206,146	75,270,884	28,547,128	18,877,164	174,337,972
1962	45,954,329	229,956	63,085,330	70,655,570	24,666,684	15,905,464	157,412,003
1961	43,728,754	240,811	60,997,367	68,317,051	25,418,364	16,607,745	154,312,725
1960	46,408,307	292,928	73,030,945	81,794,658	27,179,458	14,134,959	169,810,310
1959	46,875,327	353,122	51,450,731	57,624,819	26,159,660	13,609,452	144,622,380
1958	44,679,937	270,058	54,798,230	61,374,018	22,496,239	12,625,829	141,446,081
1957	56,324,891	454,881	87,278,815	97,752,273	30,439,375	11,234,810	196,206,230
1956	56,785,903	588,782	80,195,929	89,819,440	30,753,412	14,330,454	192,277,991
1955	52,906,161	472,171	89,169,973	99,870,369	29,722,293	10,787,786	193,758,780
1954	46,081,293	285,874	60,791,697	68,088,941	24,975,440	11,866,241	151,297,789
1953	50,753,100	281,613	95,844,449	107,345,783	26,999,207	14,317,229	199,696,932
1952	45,763,756	520,436	74,910,798	83,900,094	23,277,942	15,214,778	168,677,006
1951	50,426,652	519,004	89,092,012	99,783,053	25,871,319	13,150,144	189,750,172
1950	56,862,000	778,222	78,205,592	87,587,471	23,395,011	9,327,450	177,950,154
1949	40,149,123	780,442	69,556,269	77,903,021	20,322,136	12,542,565	151,697,287
1948	59,241,228	1,322,302	82,937,192	92,889,655	22,282,425	9,876,880	185,612,490
1947	56,870,546	1,189,338	77,898,087	87,245,857	20,891,130	11,409,228	177,606,099
1946	52,361,722	1,364,809	59,356,716	66,479,522	17,551,555	10,197,850	147,955,458
1945	53,670,837	1,575,360	75,714,750	84,800,520	16,318,193	18,717,773	175,082,683
1944	58,747,203	1,416,127	81,170,538	90,911,003	16,856,279	16,228,880	184,159,492
1943	51,120,475	848,984	84,404,852	94,533,434	17,339,675	11,810,116	175,652,684
1942	51,623,848	909,949	92,076,781	103,125,995	18,570,048	8,501,586	182,731,426
1941	52,566,163	969,202	80,116,360	89,730,323	17,633,448	11,387,480	172,286,616
1940	48,517,632	801,972	63,712,982	71,358,540	14,893,316	9,644,950	145,216,410
1939	39,836,786	531,335	45,072,724	50,481,451	12,208,205	11,172,079	114,229,856
1938	34,172,963	450,324	19,263,011	21,574,572	8,240,768	10,679,125	75,117,752
1937	43,644,997	673,768	62,598,836	70,110,696	14,429,379	5,829,399	134,688,239
1936	44,010,585	688,858	44,822,023	50,200,666	12,080,672	7,433,967	114,414,748
1935	34,730,099	559,036	28,362,368	31,765,852	9,082,155	6,750,261	82,887,403
1934	34,869,536	607,039	22,249,600	24,919,552	7,392,218	7,951,145	75,739,490
1933	31,351,353	425,301	21,623,898	24,218,766	6,664,629	8,713,127	71,373,176
1932	24,563,391	293,978	3,567,985	3,996,142	3,928,840	8,890,409	41,672,761
1931	30,415,291	761,068	23,467,786	26,283,920	7,208,946	9,479,640	74,148,865
1930	36,839,923	1,232,137	46,582,982	52,172,940	12,432,628	9,851,229	112,528,857
1929	37,933,249	1,321,329	65,204,600	73,029,152	16,269,612	10,021,099	138,574,441

[a]Includes Canadian and United States traffic.

[b]Coal figures from 1940 corrected to include Lake Michigan and Lake Ontario movement.

[c]Gross Tons (2,240 lbs.)

SOURCE: The Hanna Mining Company, Agents - February 15, 1971.

exemplified by the six ore docks at Duluth-Superior, generally consists of high-level piers, which load vessels by gravity feed from on-pier storage bins. The vessel can also be loaded directly from rail cars moving on and off the pier. These high-level finger piers are equipped with specially designed pockets. They accept the ore from the rail cars and drop it via chutes into vessels moored alongside. The average loading speed for this type of facility is approximately 3,000 tons per hour. Loading speed is governed primarily by the need to avoid overstressing the vessel hull. Figure C9–8 shows taconite being loaded by gravity feed system.

A more recently constructed type of ore loading facility generally operates at specialized bulk ports such as Taconite Harbor and Silver Bay. These ports are the outlets for the high grade iron ore pellets produced by a complex concentrating process from taconite or jasper. Both Silver Bay and Taconite

TABLE C9–28 Total Traffic Carried on the Great Lakes and Connecting Channels by Area, 1959 to 1970 (Millions of Tons)

Area	1959	1960	1961	1962	1963	1964	1965	1966	1967	1970
Lake Superior	60.3	81.8	68.9	70.0	72.7	77.9	78.7	85.3	75.4	78.8
St. Marys River	65.9	86.6	74.2	74.5	77.4	83.7	81.3	87.3	77.9	81.1
Lake Michigan, including the Port of Chicago (Chicago Harbor, North Branch, South Branch, Sanitary Ship Canal, Calumet-Sag Canal, Calumet Harbor and River, and Lake Calumet)	81.5	92.0	85.4	85.1	107.4	117.7	117.5	125.9	124.6	131.1
Lake Huron	106.4	126.0	113.8	114.9	122.7	136.7	138.9	148.0	136.0	141.3
St. Clair River, including Channels in Lake St. Clair	78.9	97.2	84.6	87.2	93.0	103.5	107.0	113.9	101.0	109.2
Detroit River	92.6	111.2	96.2	100.0	107.2	120.3	124.5	129.2	118.5	125.6
Lake Erie, including Upper Niagara River	100.7	114.9	101.0	107.4	120.2	134.5	140.6	147.5	136.6	142.7
Welland Canal	21.0	21.7	21.5	27.5	31.1	38.9	40.6	43.8	41.7	45.7
Lake Ontario, including Lower Niagara River	21.4	22.1	21.7	28.0	33.1	38.8	41.0	43.1	41.0	45.1
St. Lawrence River, between International Boundary Line and Lake Ontario	12.5	12.0	12.8	16.3	19.4	25.6	27.7	29.5	27.9	30.9
Net United States Traffic on the Great Lakes				184.3	209.5	213.3	217.5	231.7	217.3	228.2

Harbor use conveyer belt loading systems to load iron ore pellets into ships. The conveyers are impressive in their performance, averaging 6,000 tons per hour. The major Canadian iron ore ports such as Sept Iles, Pointe Noire, and Port Cartier also use these high-speed, belt-loading conveyer systems (see references 17 and 53).

Once the ore carrier arrives at ports on the lower Lakes, the ore is transferred from the vessel by shore-based cranes, usually of the specially-designed Hulett type. Once out of the vessel, the ore is either fed through a high-level hopper into waiting rail cars or into a system that places the ore in storage. The traditional method for handling storage ore has been large bridge cranes, but there is a trend to use of conveyer systems.

Unloaders are usually employed in groups or batteries of three to five machines on one dock. Individual machine rates are approximately 600 to 750 tons per hour. Average for a battery (the total dock rate) is approximately 3,000 tons per hour. Figure C9–9 shows iron ore being unloaded at a Lake Erie dock.

TABLE C9–29 Great Lakes Area Iron Ore Shipments[a]

Year	Shipments (tons)	Nat. Iron (%)	Silica (%)	Moisture (%)
	Mesabi Range			
1924	28,850,000	51.93	8.08	11.35
1933	13,355,000	51.26	8.77	11.55
1955	66,504,000	50.43	10.21	11.26
1960	52,087,000	54.10	9.03	8.31
1965	49,172,000	56.66	8.32	6.62
1970	54,717,000	58.93	7.36	5.26
	U. S. Ranges - Great Lakes Region			
1924	43,276,000	51.72	8.46	10.75
1933	21,455,000	51.85	8.96	10.47
1955	85,405,000	50.63	10.11	10.81
1960	67,439,000	53.84	8.90	8.26
1965	64,689,000	56.93	8.14	6.05
1970	69,072,000	59.26	7.38	4.64
Total U. S. Shipments--				
1970	87,389,000	59.31	7.31	4.10
	Canadian Regions			
1960	19,445,000	53.64	7.98	7.10
1965	35,883,000	60.24	5.92	3.67
1970	47,824,000	61.83	5.59	3.05

[a]Rail and water shipments.

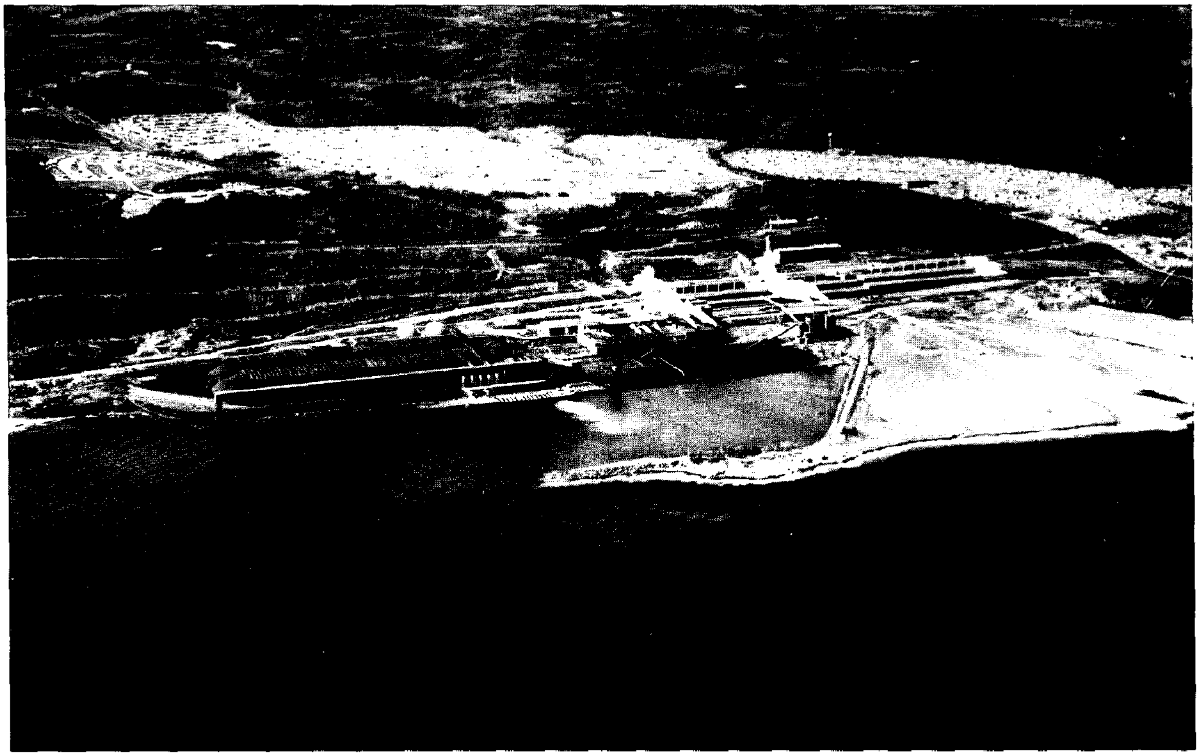
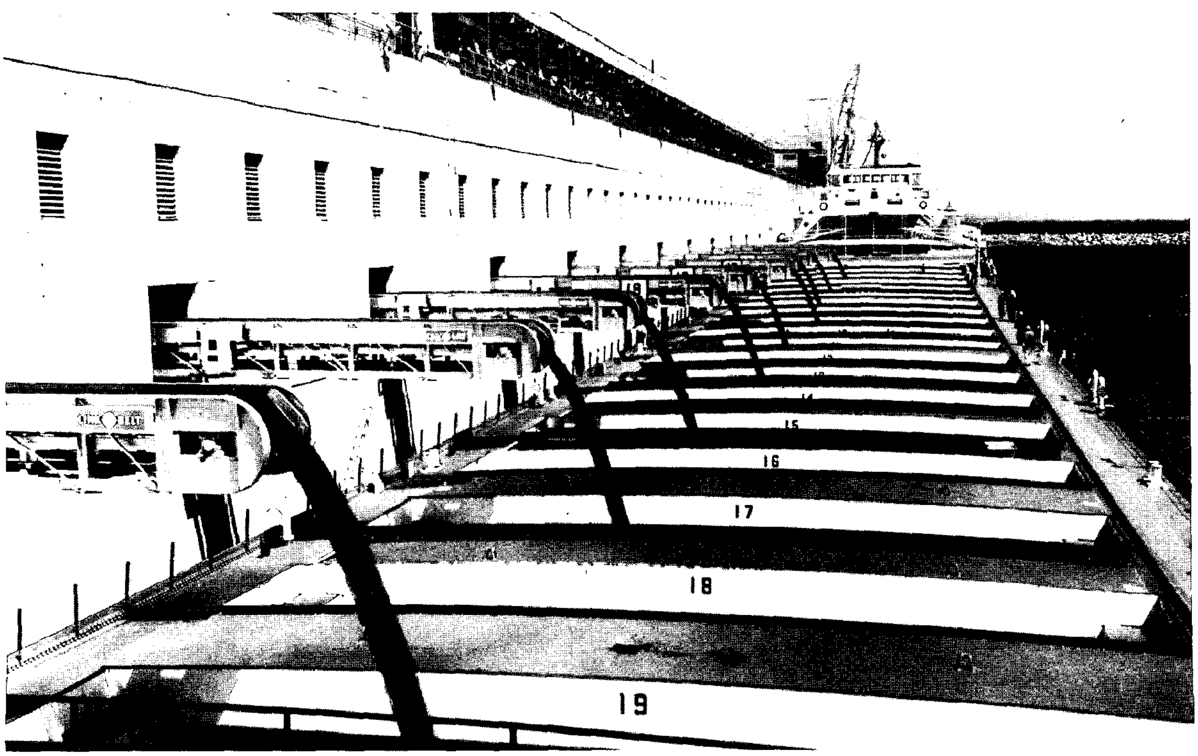


FIGURE C9–7 Taconite Plant at Silver Bay Harbor, Minnesota Courtesy of U.S. Army Corps of Engineers

FIGURE C9–8 Loading Taconite by Typical Gravity Feed Loading System at New Duluth Dock
Courtesy of Lake Carriers' Association



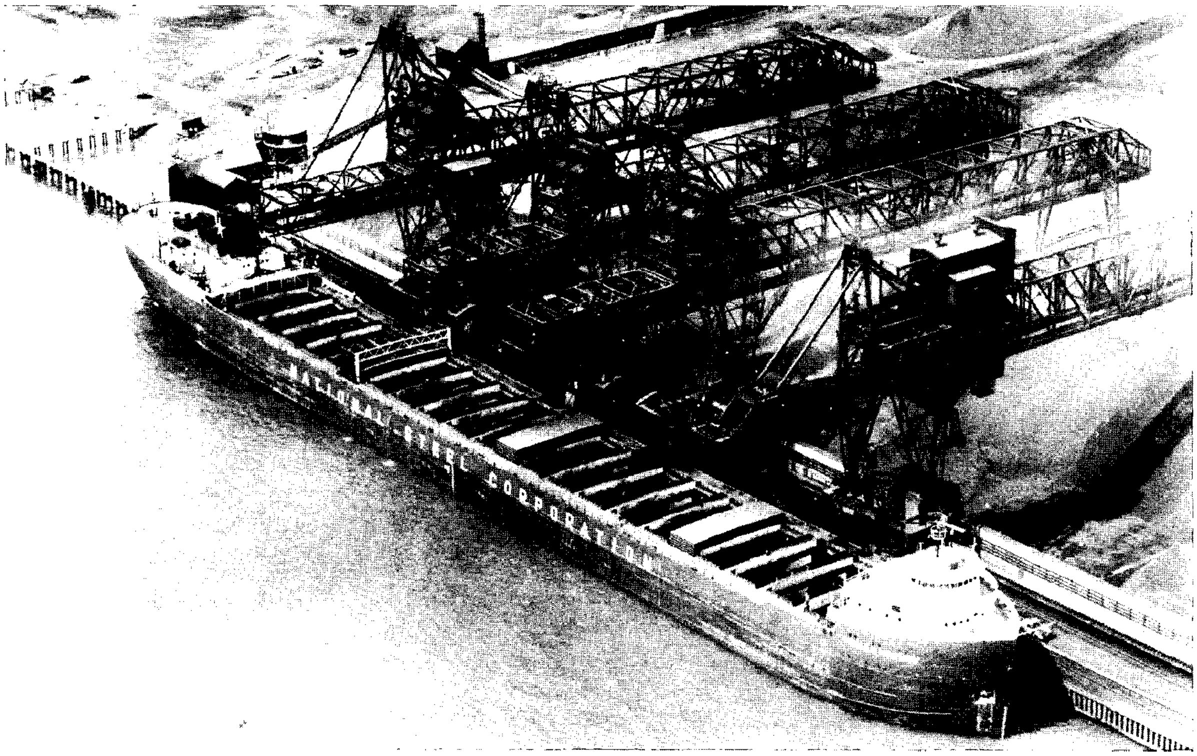


FIGURE C9–9 Unloading Iron Ore at a Lake Erie Dock

Courtesy of General Electric

FIGURE C9–10 Ore Unloading and Coal Loading Docks at Toledo, Ohio

Courtesy of Lake Carriers' Association

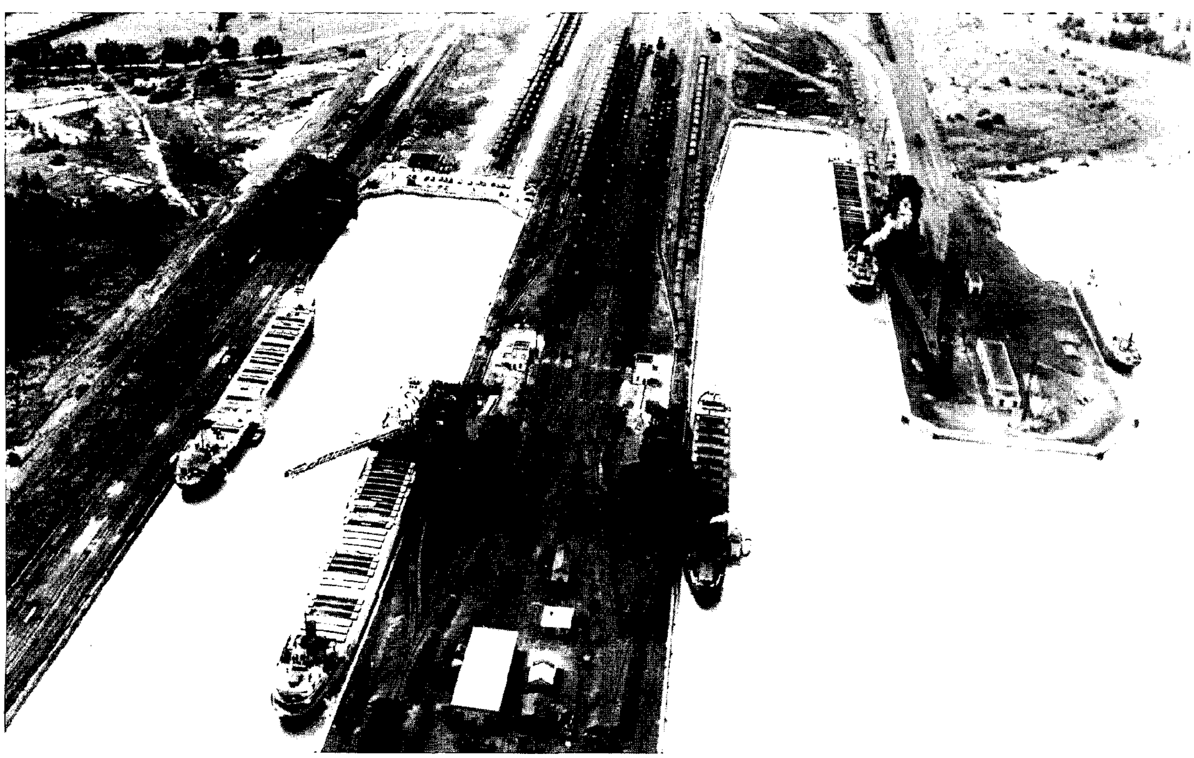


TABLE C9-30 World Production of Iron Ore in 1970

Continent	Short Tons (millions)
North America	156
South America	81
Europe	374
Asia	100
Africa	68
Oceanic	51
Total	830

3.1.3 Coal

Coal traffic is concentrated on Lake Erie, with Huron, Michigan, and Ontario having lesser roles. Coal movement on Lake Ontario is accomplished with large modern vessels. Toledo is the most important loading port, although the net tonnage leaving the terminal has decreased from 35 million tons in 1965 to 15 million tons in 1972. This fact reflects the accelerated inroads of unit train competition, the shift to eastern Lake Erie ports, and the effect of environmental controls on use of high sulphur coal. Destinations for coal are generally areas where electric utilities and the iron and steel industry are predominant. Western Lake Erie ports in the U.S. and a stretch along the Detroit River consume substantial amounts of coal. In Canada major receiving ports for coal are Hamilton, with its steel center, and Toronto, with its coal-consuming public utilities.[53]

The vast majority of coal moving in the Great Lakes Region leaves the mine in rail cars. At a central point these coal cars are assembled into trains and line-hauled to a Great Lakes port for transshipment. For many years the procedure was to move the cars into dumping positions on the pier and unload. These standard coal loading docks tower high above the decks of the vessels. Their large conveyers and chutes move thousands of tons of coal an hour. Toledo, the Great Lakes largest coal port, has six coal loading docks[17] (Figure C9-10). One uses a conveyer handling system that achieves a maximum vessel loading rate of 4,500 tons per hour. The other five use the car dump unloaders, which average 2,280 tons per hour. As is the case with iron ore, specialized coal bulk ports illustrate efficient loading. The ports of Sandusky, Ashtabula, and Conneaut have changed their methods to modern conveyerized loading systems capable of transferring coal at an average rate of 8,000 tons per hour. Here rail cars are unloaded promptly onto a conveyer system. The coal can be loaded directly into a vessel, but normally it is sent to a stockpile. When a vessel arrives, the coal is reclaimed by conveyer and loaded. This system eliminates need for close coordination of rail and vessel movements. Coal can be received all winter and stockpiled for shipment in the spring when navigation opens. Mines supplying lake coal can thus operate year-round, offering important economic savings. Railroad car demurrage also is reduced. Vessel time in port is reduced significantly. The coal is generally loaded onto self-unloaders, which have their own, usually conveyerized, unloading system.

The ten Port of Detroit unloading docks that receive the greatest volume of coal are equipped to receive only self-unloaders and have available storage capacity of approximately 2.3 million tons. At Duluth-Superior five of the six coal docks use shore-based unloading cranes, which operate in the 600 to 900 tons-per-hour range, while one coal dock accepts self-unloaders. At Hamilton, the largest Canadian recipient of coal, three of the unloading docks require the use of self-unloaders, while the other two use bucket cranes handling coal at the rate of 325 tons per hour. The docks at Hamilton have a combined storage capacity of 590,000 tons.[53]

This vessel-to-storage movement at the receiving port is usually supplemented only by a local transfer of the coal from storage to consuming furnace. Tonnages and facilities at major U.S. and Canadian coal ports are shown in Table C9-33.

3.1.4 Limestone

Like coal, virtually no limestone is shipped overseas through the Seaway, but almost all limestone traffic is shipped by Lake. The major loading ports for limestone are Calcite (Figure 9-11), Stoneport, and Port Inland, Michigan. Port Dolomite, Michigan, is a major port for loading dolomite. Most of the traffic is unloaded near steel mills at Detroit, Gary, Chicago, and Cleveland.[53]

(Continued on page 52)

TABLE C9–31 Shipments of Iron Ore Pellets

Year	Shipments (tons)	Nat. Iron (%)	Silica (%)	Moisture (%)	Percent of Total Ore Shipments
United States Regions					
1962	17,503,000[a]	61.52	7.97	2.64	26.5
1963	23,224,000[a]	61.74	7.97	2.18	32.3
1964	28,852,000[a]	61.96	7.67	2.10	35.1
1965	30,786,000[a]	62.05	7.55	2.10	37.2
1966	29,361,000[b]	61.38	7.94	2.70	42.1
	36,301,000[a]	61.90	7.27	2.41	41.0
1967	33,913,000[b]	61.85	7.29	2.70	53.1
	41,347,000[a]	62.25	6.79	2.44	50.6
1968	39,639,000[b]	62.12	7.04	2.73	61.9
	46,885,000[a]	62.49	6.68	2.46	57.6
1969	45,402,000[b]	62.38	6.86	2.39	63.6
	53,475,000[a]	62.66	6.59	2.18	59.6
1970	45,658,000[b]	62.38	6.87	2.45	66.1
	53,740,000[a]	62.63	6.61	2.26	61.5
All Canadian Regions[c]					
1962	1,146,000	65.90	1.50	0.03	4.8
1963	3,183,000	65.15	3.82	0.45	11.8
1964	6,359,000	64.44	4.33	1.34	18.5
1965	9,171,000	64.50	4.40	1.25	25.6
1966	11,258,000	64.33	4.37	1.47	30.8
1967	15,677,000	64.18	4.61	1.40	41.2
1968	20,702,000	65.11	4.68	1.48	48.4
1969	18,796,000	64.26	4.74	1.37	52.1
1970	24,186,000	64.12	4.87	1.39	50.6

[a]Total U.S. Shipments

[b]Great Lakes Area Shipments

[c]Total Canadian Shipments

TABLE C9–32 Major Iron Ore Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

			Foreign		Domestic		
	Facilities	Total	Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Cleveland, Ohio	5	16,649	---	3,658	---	12,991	---
Port of Detroit	2	10,560	---	1,024	---	9,536	---
Port of Chicago	5	9,612	---	1,223	---	8,330	59
Indiana Harbor, Ind.	2	9,297	---	2,776	---	6,521	---
Gary, Ind.	1	8,736	---	---	---	8,736	---
Port of Buffalo	3	8,213	---	1,269	---	6,944	---
Conneaut, Ohio	1	6,992	---	1,897	---	5,095	---
Toledo, Ohio	6	5,443	---	---	---	5,443	---
Ashtabula, Ohio	1	5,250	---	1,070	---	4,180	---
Lorain, Ohio	1	3,421	---	214	---	3,207	---
Huron, Ohio	1	2,427	---	---	---	2,427	---
Burns Waterway, Ind.	1	1,499	---	---	---	1,499	---
Total		88,099	0	13,344	0	74,696	59
Percent of Total		100%	---	15%	---	85%	---
U.S. Shipping Ports							
Duluth-Superior	6	32,352	---	732	---	31,620	---
Taconite Harbor, Minn.	1	11,636	---	---	---	11,636	---
Silver Bay, Minn.	1	10,995	---	---	---	10,995	---
Escanaba, Mich.	1	9,864	---	---	---	9,864	---
Two Harbors, Minn.	1	5,246	---	---	---	5,246	---
Presque Isle, Mich.	1	3,816	---	116	---	3,700	---
Total		73,909	0	848	0	73,061	0
Percent of Total		100%	---	1%	---	99%	---

			Foreign		Domestic
	Facilities	Total	U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Hamilton	2	5,986	1,594	10	4,382
Sault Ste. Marie	1	1,889	381	---	1,508
Total		7,875	1,975	10	5,890
Percent of Total		100%	25%	0.1%	74.9%
Canadian Shipping Ports					
Sept Iles	2	23,007	21,947	---	1,060
Port Cartier	1	9,964	9,957	---	7
Thunder Bay	2	5,766	2,739	---	3,027
Pointe Noire	1	5,765	2,964	---	2,801
Total		44,502	37,607	0	6,895
Percent of Total		100%	85%	---	15%

SOURCES: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

TABLE C9-33 Major Coal Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

	Facilities	Total	Foreign		Domestic		
			Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Port of Detroit	10	9,014	---	---	---	9,014	---
Port of Chicago	1	6,330	---	---	---	---	6,330
St. Clair River, Mich.	1	4,808	---	---	---	---	4,808
Green Bay, Wis.	6	1,890	---	---	---	1,890	---
Duluth-Superior	6	1,816	---	---	---	1,816	---
Milwaukee, Wis.	10	1,662	---	---	---	1,662	---
Muskegon, Mich.	4	1,642	---	---	---	1,642	---
Saginaw River, Mich.	1	1,567	---	---	---	1,567	---
Oak Creek, Wis.	1	1,218	---	---	---	1,218	---
Port of Buffalo	3	1,039	---	---	---	1,039	---
Port Washington, Wis.	1	1,023	---	---	---	1,023	---
Alpena, Mich.	1	791	---	---	---	791	---
Total		32,800	0	0	0	21,662	11,138
Percent of Total		100%	---	---	---	66%	34%
U.S. Shipping Ports							
Toledo, Ohio	6	21,639	---	3,944	---	17,695	---
Conneaut, Ohio	1	7,545	---	5,856	---	1,689	---
Port of Chicago	1	6,342	2	21	---	6,319	---
Ashtabula, Ohio	1	5,571	---	4,641	---	930	---
Sandusky, Ohio	2	4,845	---	3,525	---	1,320	---
Lorain, Ohio	1	3,127	---	52	---	3,075	---
Total		49,069	2	18,039	0	31,028	0
Percent of Total		100%	---	37%	---	63%	---

	Facilities	Total	Foreign		Domestic
			U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Hamilton	5	4,484	4,307	---	177
Port Credit	1	3,801	3,801	---	---
Sarnia	6	3,399	3,377	---	22
Sault Ste. Marie	4	2,349	2,322	---	27
Toronto	5	1,615	1,615	---	---
Windsor	3	1,042	796	---	246
Montreal	3	340	337	---	3
Total		17,030	16,555	0	475
Percent of Total		100%	97%	---	3%
Canadian Shipping Ports					
No major shipping ports					

SOURCES: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

FIGURE C9–11 Limestone Loading Docks at Calcite, Michigan

Limestone is a low-value commodity, with an inability to support much transportation cost. Fortunately limestone is not only produced at lakeside, it is generally consumed at or near lakeside, too, which minimizes the cost of getting it to or from lake vessels. These two factors have resulted in the development of a sophisticated triangular movement of coal and limestone, designed to provide viable, low-cost transportation. Coal moves via self-unloaders out of Lake Erie ports or Chicago destined for lakeside cities on Lakes Michigan or Huron. Once the coal is unloaded, the self-unloaders move in ballast to a port where they load limestone and then sail to its port of destination. Because this enables the vessel to sail with as high a load factor as possible, it reduces the overall transportation cost. Tonnages and facilities at major limestone ports on the Great Lakes are shown in Table C9–34 (see references 17 and 48).

3.1.5 Fuel Oil

The great Canadian demand for fuel oil is the impetus for most of the fuel oil movement on the Great Lakes. Almost half the fuel oil unloaded in the Great Lakes-St. Lawrence Seaway are imports destined for Canadian consumption.[53]

Ontario receives fuel oil from two basic sources, western Canada and foreign supplies. Pipelines transport the western crude to Sarnia and Toronto for refining, and the fuel output is then shipped along the Lakes or exported to the U.S. Imported fuel oil is received either from cargoes transshipped at Montreal or directly from foreign sources. Direct import sources include the United States, Europe, and the Caribbean, while additional imports originate from within the Lakes system at Lake Erie and Lake Michigan ports.

The movement of fuel oil is another salient example of a complementary relationship between several modes of transportation, pipeline, lake vessel, and truck. The transportation sequence begins when the crude oil is delivered by pipeline to refineries serving the Great Lakes. Among the major crude oil sources are Texas, Oklahoma, and Louisiana in the United States, and Alberta in Canada. The crude oil is piped to major refineries in the Chicago, Central Michigan, Detroit, Toledo, Buffalo, and Duluth-Superior areas in the U.S., and Sarnia and Toronto in Canada.

TABLE C9–34 Major Limestone Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

	Facilities	Total	Foreign		Domestic		
			Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Port of Detroit	10	5,753	---	---	---	5,753	---
Cleveland, Ohio	11	2,443	---	---	---	2,443	---
Port of Chicago	8	2,273	---	---	---	2,273	---
Indiana Harbor, Ind.	3	2,256	---	---	---	2,256	---
Fairport, Ohio	7	2,151	---	---	---	2,151	---
Port of Buffalo	7	2,053	---	---	---	2,053	---
Buffington, Ind.	1	1,905	---	---	---	1,905	---
Saginaw River, Mich.	5	1,631	---	---	---	1,631	---
Ludington, Mich.	1	1,552	---	---	---	1,552	---
Gary, Ind.	2	1,341	---	---	---	1,341	---
Lorain, Ohio	1	1,255	---	---	---	1,255	---
St. Clair River, Mich.	1	825	---	---	---	825	---
Total		25,438	0	0	0	25,438	0
Percent of Total		100%	---	---	---	100%	---
U.S. Shipping Ports							
Calcite, Mich.	3	13,432	---	---	---	13,432	---
Stoneport, Mich.	1	7,088	---	---	---	7,088	---
Port Inland, Mich.	1	4,881	---	---	---	4,881	---
Port Dolomite, Mich.	1	3,609	---	---	---	3,609	---
Drummond Island, Mich.	2	2,527	---	125	---	2,402	---
Marblehead, Ohio	1	1,659	---	---	---	1,659	---
Kelleys Island, Ohio	1	508	---	---	---	508	---
Total		33,704	0	125	0	33,579	0
Percent of Total		100%	---	0.4%	---	99.6%	

	Facilities	Total	Foreign		Domestic
			U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Clarkson	1	1,670	---	---	1,670
Sault Ste. Marie	3	486	486	---	---
Windsor	3	333	323	10	---
Total		2,489	809	10	1,670
Percent of Total		100%	33%	0.5%	66.5%
Canadian Shipping Ports					
Marble Bay	1	727	647	---	80
Blubber Bay	1	596	548	---	48
Total		1,323	1,195	0	128
Percent of Total		100%	90%	---	10%

SOURCES: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

In most cases the refineries are located either directly on the Great Lakes-Seaway or on tributary bodies of water. Fuel oil and other products are pumped from refinery storage tanks into waiting barges and tankers. These vessels then proceed to their demand points and unload into storage tanks, from which final delivery is made, normally by tank truck. Other refined products move by water either to small markets not reached by product pipelines or as a means of equalizing temporary imbalances between local supplies and demands. Heavy fuel oils are frequently transported by water to the Great Lakes area. They are not well suited to pipeline movement because of high viscosity and pipeline contamination problems.

The Port of Chicago has two petroleum docks.[17] One at Calumet Harbor provides a combination loading and unloading facility. The second is an unloading facility at the City of Chicago. Their combined storage capacity is approximately 700,000 barrels. Of the seven petroleum docks at Indiana Harbor, a major U.S. petroleum port, six are equipped for loading and one is for both loading and unloading. The combined storage capacity for the docks is approximately 15.7 million barrels.

Montreal, an important Canadian fuel port, has 11 petroleum docks, all but one of which are equipped to handle both loading and unloading of cargo. Their combined storage space is 23.0 million barrels. Tonnage and facilities at major petroleum ports on the Great Lakes-Seaway System are shown in Table C9–35.

3.1.6 Grain

3.1.6.1 General

Historically, 50 percent to 70 percent of U.S. grain shipments are for export. The Seaway system is now the least expensive shipping channel for most U.S. grain exports grown within North Dakota, parts of Montana, Wyoming, South Dakota, Iowa, and parts of the Great Lakes grain producing border States. Since the opening of the St. Lawrence Seaway in 1959, it is apparent that a substantial shift in the U.S. export grain markets has occurred, largely at the expense of the North Atlantic ports (Table C9–36). It should be noted when comparing Table C9–36 with Table C9–39, that Table C9–36 includes total U.S. grain production, whereas Table C9–39 includes grain production in the Great Lakes hinterland only.

3.1.6.2 Wheat

Thunder Bay and Duluth-Superior are by far the two largest wheat loading ports on the Great Lakes. They are the outlets for the midcontinent of North America, the world's largest supplier of wheat. Figure C9–12 shows grain being loaded into a vessel at Duluth Harbor.

Most Canadian wheat moved along the Seaway is loaded on lakers at Thunder Bay. Wheat destined for foreign export is shipped to Montreal or other ports on the lower St. Lawrence where it is reloaded on larger ocean ships for the final leg of its overseas journey. More than 85 percent of the Canadian wheat exports are shipped to Northern and Eastern Europe, the U.S.S.R., and South Asia,[53] as shown in Table C9–37. Approximately 50 percent of all Canadian wheat exports move through the Seaway system. The practice of transshipping at Montreal became popular when the Quebec-Labrador iron ore mines began to develop. It soon became apparent that unit costs of the lake vessels could be substantially reduced by providing a return haul of iron ore to ports on Lake Erie.

Approximately 22 percent of the Canadian wheat shipped via the Great Lakes-Seaway system is consumed domestically.[10] This domestic Canadian wheat moves in patterns similar to those of foreign wheat, and reaches storage points on the lower St. Lawrence.

The United States shipped only 8.4 percent of its wheat exports in 1971 via the Seaway. The twin ports of Duluth-Superior handle the majority of U.S. wheat traffic. In 1970 this amounted to 3.0 million tons.[48] More than half of U.S. wheat exports via the Seaway are destined for Northern Europe and North Africa (Table C9–38). Roughly 55 percent of American wheat shipped over the Great Lakes is consumed domestically.[10] The majority of the American domestic wheat is unloaded at Buffalo with its large milling complex, although smaller quantities do go to Detroit, Cleveland, and Chicago. In 1968 comparable charges for shipping a bushel of wheat from Duluth to Buffalo were 11¢ by laker, 20¢ by unit train, and 46¢ by single railroad car.

Although the Seaway system is the most competitive route for exported barley, rye, and spring and durum wheats from the upper middlewest hinterland, as shown by its share

TABLE C9-35 Major Petroleum Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

			Foreign		Domestic		
	Facilities	Total	Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Port of Chicago	2	4,280	---	---	---	1,079	3,201
Milwaukee, Wis.	7	919	---	---	---	917	2
Muskegon, Mich.	5	864	---	---	---	864	---
Port of Buffalo	2	348	---	42	---	271	35
Indiana Harbor, Ind.	7	344	---	---	---	318	26
Total		6,755	0	42	0	3,449	3,264
Percent of Total		100%	---	1%	---	51%	48%
U.S. Shipping Ports							
Indiana Harbor, Ind.	7	5,005	---	---	---	4,973	32
Port of Chicago	2	1,353	---	5	---	696	652
Toledo, Ohio	5	470	---	38	---	429	3
Port of Detroit	2	389	---	---	---	389	---
Port of Buffalo	2	304	---	---	---	234	70
Total		7,521	0	43	0	6,721	757
Percent of Total		100%	---	0.6%	---	89.4%	10%

			Foreign		Domestic
	Facilities	Total	U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Quebec	6	2,655	1,307	---	1,348
Montreal	11	2,359	2,155	---	204
Toronto	9	933	---	173	760
Trois Rivieres	1	805	450	---	355
Hamilton	3	727	9	73	645
Sept Iles	4	722	521	---	201
Sault Ste. Marie	1	418	16	---	402
Windsor	3	412	---	---	412
Sorel	1	289	59	---	230
Clarkson	1	288	---	81	207
Sarnia	6	155	---	26	129
Total		9,763	4,517	353	4,893
Percent of Total		100%	46%	4%	50%
Canadian Shipping Ports					
Montreal	11	5,914	407	---	5,507
Sarnia	6	2,281	56	---	2,225
Thunder Bay	2	400	---	---	400
Clarkson	1	364	59	---	305
Quebec	6	269	23	---	246
Toronto	9	181	---	---	181
Total		9,409	545	0	8,864
Percent of Total		100%	6%	---	94%

SOURCES: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

TABLE C9–36 Grains: Inspections for Export by Coastal Areas, 1958, 1968, and 1971

Type of Grain		Total (Millions of Net Tons)	Percent of Total: Great Lakes Ports	Atlantic Ports	Gulf Ports	Pacific Ports
Total	1958	-	3.7	22.6	52.4	21.3
	1968	45.4	15.3	9.3	62.5	12.9
	1971	47.4	17.8	5.5	65.4	11.3
Wheat	1958	-	-	24.9	48.5	26.6
	1968	16.5	9.4	6.6	50.7	33.3
	1971	16.7	8.4	2.4	62.5	26.7
Oats	1958	-	-	54.1	37.2	8.7
	1968	0.098	92.0	-	8.0	-
	1971	0.084	85.9	-	14.1	-
Barley	1958	-	0.2	18.6	20.8	60.4
	1968	0.4	28.7	12.3	0.9	58.1
	1971	1.4	38.4	-	7.6	54.0
Rye	1958	-	3.9	50.8	23.7	21.6
	1968	0.05	85.3	-	14.7	-
	1971	0.15	92.0	0.7	7.3	-
Flaxseed	1958	-	93.1	0.9	6.0	-
	1968	0.25	92.2	-	7.8	-
	1971	0.008	100.0	-	-	-
Corn	1958	-	9.8	28.6	58.9	2.7
	1968	16.2	20.9	14.9	64.2	-
	1971	14.0	23.5	13.5	63.0	-
Grain Sorghums	1958	-	-	-	96.8	3.2
	1968	3.7	0.3	-	96.1	3.6
	1971	3.2	-	-	95.1	4.9
Soybeans	1958	-	11.3	17.6	71.1	-
	1968	8.2	18.5	7.9	73.6	-
	1971	11.9	25.2	2.8	72.0	-

Source: USDA Grain Market News, Weekly Summary and Statistics, January 1959, 1969, and 1972.

TABLE C9–37 Canadian Wheat Exports Through the St. Lawrence Seaway, 1966

Destination Area	Tonnage short tons (thousands)	Seaway Share Total Canadian Wheat Traffic(%)
Northern Europe	2,427	64.7
Southern Europe	346	97.7
Eastern Europe & U.S.S.R.	3,863	77.3
North Africa & Near East	296	98.0
South Asia	1,104	85.2
Latin America	191	62.2
All other destinations	594	8.1
Total	8,821	47.0

SOURCE: Canadian Board of Grain Commissioners.

TABLE C9–38 U.S. Wheat Exports Through the St. Lawrence Seaway, 1966

Destination Area	Tonnage short tons (thousands)	Seaway Share Total U.S. Wheat Traffic(%)
Northern Europe	539	20.7
Southern Europe	135	35.5
Eastern Europe	38	8.5
North Africa	306	14.5
All other destinations	400	3.4
Total	1,418	7.2

SOURCE: EBS Management Consultants, Inc., An Economic Analysis of Improvement Alternatives to the St. Lawrence Seaway System, 1969, Appendix A, P. 1A-5.

of the total export market during the shipping season (Table C9–39), Gulf, Atlantic, and Pacific coast ports divert considerable tonnages during the winter months because of the additional storage costs incurred at lake ports. The limited shipping season on the Lakes prevents the Seaway from shipping more export grain.

Wheat exports via the Seaway[32] in 1970, 8.8 percent of the United States total (19,200,000 tons),[48] are shown in tabular form in thousands of tons.

WHEAT

From	Canada	Foreign	Total
United States	1,185	508	1,693
Canada	6,414	74	6,488
	7,599	582	8,181

Seaway exports have been projected to reach 3,600,000 tons or 11 percent of the nation's total by 2015.[43]

3.1.6.3 Corn

Corn has become one of the nation's fastest growing export commodities. Chicago is the major port for corn traffic, drawing its produce from the western Ohio, Indiana, Illinois, Iowa, and Nebraska corn belt. In 1970, 1–2 mil-

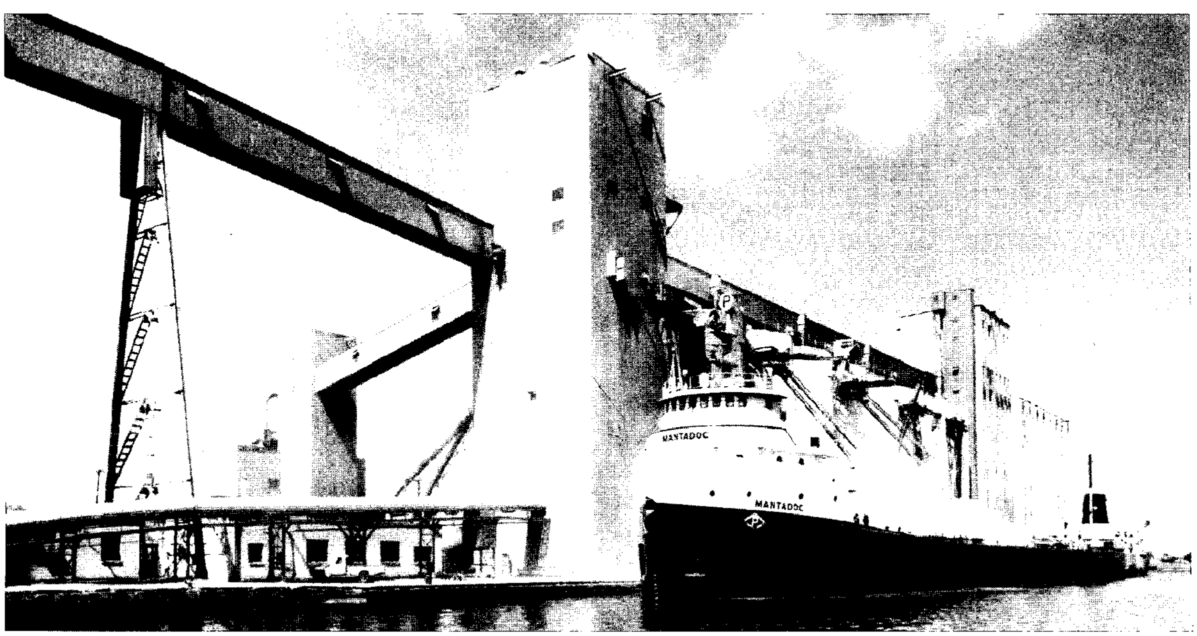


FIGURE C9–12 Grain Loading at Duluth Harbor

Courtesy of U.S. Army Corps of Engineers

TABLE C9–39 Route Distribution of Wheat, Corn, Soybeans, and Barley and Rye Shipped between May 1, 1966, and November 30, 1966

Route	Distribution in Percent[a]			
	Wheat[b]	Corn	Soybeans	Barley & Rye
Seaway System	85.5 (48.4)[c]	42.8	18.9	85.0
Atlantic Coast Ports	3.8 (28.2)	4.6	4.4	1.2
Gulf Coast Ports	9.0 (22.7)	52.6	76.7	2.6
Pacific Coast Ports	1.7 (0.7)	0.0	0.0	11.2
Total	100.0 (100.0)	100.0	100.0	100.0

[a]Includes grain from Great Lakes hinterland only.

[b]Commercial hard, red spring, and durum wheat only.

[c]Distribution for entire year (%).

SOURCE: EBS Management Consultants, Inc., An Economic Analysis of Improvement Alternative to the St. Lawrence Seaway System, 1969, Table IV-10, P. IV-20. Reference 10.

lion tons of corn passed through Chicago for export to overseas and Canadian ports. Toledo and Duluth-Superior also handle substantial amounts of corn. Much of the corn is unloaded at lower St. Lawrence ports for transshipment onto ocean-going vessels.

The domestic flow of corn is similar to the flow of wheat in that a substantial majority of the U.S. traffic is unloaded at the milling complex at Buffalo. Virtually no corn is exported from Canada, but Canada does import some from the U.S. The major recipients of the U.S. corn exports are northern and southern Europe and Japan.[53]

From 1959 to 1963 an average of 2,007,000 tons, only 23 percent of the nation's total corn exports, was exported via the Seaway,[43] although the U.S. cornbelt, producing 80 to 85 percent of the nation's corn, is located in the Great Lakes tributary area. Corn exports via the Seaway[32] in 1970, 18.5 percent of the nation's total (15,400,000 tons),[48] are shown in tabular form in thousands of tons.

CORN

From	Canada	Foreign	Total
United States	1,442	1,397	2,839
Canada	45	—	45
	1,487	1,397	2,884

Projections show that as much as 7,350,000 tons or 40 percent of U.S. corn exports will move via the Seaway by 2015.[43]

3.1.6.4 Soybeans

Soybeans flow in a pattern roughly similar to that of corn. Toledo and Chicago handle 85 percent of the soybean exports passing through the Seaway stream. The amount of soybeans exported via the Seaway accounts for only 20 to 24 percent of the U.S. soybean export. There is virtually no U.S. domestic soybean cargo. The major recipients of soybeans, as with corn, are countries in northern and southern Europe and Japan. The surprisingly large share of soybean exports to Japan is due to the fact that vessels carrying Japanese steel imports can reload their ships with soybeans.

In the period 1959 to 1963, approximately 913,000 tons of soybeans were exported via the Seaway.[43] This is only 20 percent of the nation's exports, although 50 percent of U.S. soybeans are grown in central Illinois, Indiana, and Ohio. Exports of soybeans via and the Seaway[32] in 1970 comprise 18.8 percent of the U.S. total (12,900,000 tons)[48] and are shown in tabular form in thousands of tons.

SOYBEANS

From	Canada	Foreign	Total
United States	1,662	769	2,431
Canada	51	2	53
	1,713	771	2,484

The Gulf ports handle the majority of U.S. corn and soybean exports not only on a year-round basis as indicated in Table C9–36, but even when the Seaway system is open for shipping as Table C9–39 points out. A comparison of Tables C9–36 and C9–39 reveals that the Seaway's short shipping season has a significantly greater impact on diversion of corn exports to the gulf coast than on soybeans. During the shipping season U.S. corn exports tend to split almost evenly between the Seaway and Gulf ports, while soybeans move predominantly south. Projections[43] show that by 2015 as much as 30 percent (3,200,000 tons) of U.S. soybean exports may move via the Seaway.[43]

3.1.6.5 Barley and Rye

The flow of barley and rye on the Seaway approximates that of wheat, but there is a substantial quantity of barley that terminates in U.S. ports such as Milwaukee and Chicago where it is used in the production of malt. A very large portion of Canadian barley and rye is transshipped in the lower St. Lawrence River. A relatively high portion of American barley and rye is taken directly overseas from Lake Superior, with a certain quantity transloaded at lower St. Lawrence ports. Northern and southern Europe are the major recipients of these commodities.[53]

Barley and rye exports via the Seaway average 681,000 tons annually or approximately 30 percent of total U.S. exports (1959–63).[43] Projections show that approximately 43 percent (1,475,000 tons) will be exported via the Seaway by 2015.[43] United States shipments of barley and rye [32] in 1970 (via the Seaway) are shown in tabular form in 1,000 tons. This was approximately 86 percent of the nation's 1970 export (1,278 tons).[48]

BARLEY

From	Canada	Foreign	Total
United States	1,008	94	1,102
Canada	2,650	229	2,879
	3,658	323	3,981

RYE

From	Canada	Foreign	Total
United States	—	1	1
Canada	38	14	52
	38	15	53

3.1.6.6 Cargo Handling Systems

Several intermediate steps are involved in transfering grain from the area of production to the area of distribution. After trucks move the grain to a nearby country elevator, it is transported by rail to a major Seaway terminal market. From there, either an ocean vessel carries the grain directly to its overseas destination or a laker shifts the cargo to the lower St. Lawrence for transshipment via ocean vessel to its foreign distribution port.

Thunder Bay's 24 grain elevators provide one of the world's largest concentrations of grain storage. These 24 grain elevators, which can hold more than 105 million bushels at one time, are functional, though quite old. Nearly all the grain facilities have been modernized since the opening of the Seaway. Duluth-Superior, the leading U.S. grain loading port, has 13 grain elevators with a total storage capacity of approximately 65 million bushels. The elevators operate with an average loading speed of roughly 25,000 bushels per hour.

Montreal is the foremost Canadian grain unloading port. The average unloading speed of its five facilities is 39,000 bushels per hour. The combined storage capacity of the elevators is 22.3 million bushels. Another leading unloading port, Buffalo, has grain elevators with a combined storage capacity of 35.5 million bushels. Their average unloading speed is 21,000 bushels per hour.

Utilization of port facilities is defined as the ratio of volume of shipments each year to the volume of storage capacity. A low ratio suggests a slow turnover of inventory, and therefore excess storage capacity. The highest 1966 to 1967 ratio was 27 at New Orleans. Other ratios were Duluth-Superior, 2.2; Chicago, 1.4; Toledo, 3.1; Albany, 1.2; Baltimore 4.7; and Norfolk, 7.7. The Gulf coast and Atlantic ports are open year-round, while Great Lakes ports are limited to eight to nine months of operation. This accounts for some of the discrepancies between lake and coastal port utilization factors. In addition, scheduling loading at ports is complicated and erratic. Nevertheless, a conservative estimate indicates that the existing storage capacity of Great Lakes ports could accommodate at least double present grain traffic.

Tonnages and facilities at major farm products (grain) ports on the Great Lakes-Seaway system are shown in Table C9–40. References 6, 10, 17, and 53 give further information regarding cargo handling systems.

3.1.7 General Cargo

The term general cargo describes all commodities that must be handled by individual unit, box, bale, or barrel and that are subject to individual mark or count.

3.1.7.1 Overseas General Cargo Traffic

The Seaway system's midwest tributary area, although landbound, generates the most overseas general cargo of any region in the U.S. Its export potential has grown rapidly.

TABLE C9–40 Major Grain Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

	Facilities	Total	Foreign		Domestic		
			Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Port of Buffalo	9	1,851	---	28	---	1,823	---
Milwaukee, Wis.	2	198	---	188	---	10	---
Total		2,049	0	216	0	1,833	0
Percent of Total		100%	---	11%	---	89%	---
U.S. Shipping Ports							
Duluth-Superior	13	6,046	1,168	2,953	---	1,935	---
Port of Chicago	7	2,386	993	1,079	2	85	227
Toledo, Ohio	3	1,888	558	1,292	---	38	---
Milwaukee, Wis.	2	529	221	192	---	116	---
Total		10,859	2,940	5,516	2	2,174	227
Percent of Total		100%	27%	51%	---	20%	2%

	Facilities	Total	Foreign		Domestic
			U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Montreal	5	3,942	320	---	3,622
Port Cartier	1	2,537	806	---	1,731
Baie Comeau	1	2,368	1,227	---	1,141
Trois Rivieres	1	1,550	771	---	779
Quebec	1	1,388	457	---	931
Sorel	1	1,189	15	---	1,174
Toronto	3	352	---	---	352
Total		13,326	3,596	0	9,730
Percent of Total		100%	27%	---	73%
Canadian Shipping Ports					
Thunder Bay	2	12,559	276	520	11,763
Montreal	5	2,712	2,712	---	---
Port Cartier	1	2,656	2,656	---	---
Baie Comeau	1	2,503	2,498	---	5
Trois Rivieres	1	1,232	1,232	---	---
Sorel	1	1,147	1,147	---	---
Quebec	1	926	921	---	5
Total		23,735	11,442	520	11,773
Percent of Total		100%	48%	2%	50%

NOTE: Includes Wheat, Corn, Barley, Rye, Oats, and Flaxseed.

SOURCE: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

As shown in tabular form, seven Great Lakes States were ranked among the 11 leading States in terms of exports of manufactured goods (dollar value) in 1969. The seven Lake States comprised 45 percent, or $29,210,000,000, of the national total.

State	($ Millions)
California	2,721
Michigan	2,613
Illinois	2,343
Ohio	2,338
New York	2,296
Pennsylvania	1,902
Texas	1,468
Indiana	999
Washington	955
Massachusetts	818
Wisconsin	785
Total	19,238
National Total	29,210

Source: 1971 Statistical Abstract of the U.S.[52]

Even though the Seaway system is a low cost overseas shipping channel, the lake ports handle less than 20 percent of the total general cargo exports generated within this highly productive area. Allegedly the lake ports face discriminatory rail rates and inequitable rail services, the same problem that plagues their export grain traffic.

Other factors holding back shipment of general cargo from the Great Lakes to overseas destinations are inertia or force of habit, lack of promotion, and seasonality. (See Subsection 1.9 on competition.)

Particularly important general cargo items are iron and steel plates, shapes, and castings. In 1970 iron and steel imports from Europe and Japan accounted for 68 percent of the general cargo traffic on the St. Lawrence River section in both directions and 74 percent of the upbound general cargo traffic. A substantial portion of the inbound iron and steel is unloaded at Detroit where cold rolled steel is used for automobiles. Chicago is close behind Detroit in total overseas iron and steel imports. Because steel and iron imports account for such a large percentage of the general cargo movement, the tonnage totals for the remaining general cargo are relatively small.

3.1.7.2 Domestic General Cargo

Domestic general cargo moving up the Seaway system primarily consists of Canadian goods destined for United States or Canadian ports. Lube oil, greases, and domestic freight traffic are important products moving between Canadian ports. Newsprint is a major Canadian export to the U.S. Downbound domestic general cargo includes domestic package freight, chemicals, and malt, which move between Canadian ports, and clay, bentonite, peas, and beans, which move from the U.S. to Canada.

There are so many variables involved with the transportation of general cargo that it is impossible to reduce them to a definite sequence. It is sufficient to say that general cargo is carried to and from the Seaway ports primarily by truck, although railroads are also involved.

3.1.7.3 Major General Cargo Ports

The Port of Chicago, the largest U.S. general cargo port on the Great Lakes, operates eight general cargo terminals at Calumet Harbor with approximately 10,000 feet of wharf. The Calumet Harbor piers provide heavy lift cranes. There are also three other general cargo terminals in downtown Chicago, which depend entirely on ship's gear for cargo handling. Detroit has four general cargo terminals, which provide an open storage area of 3,395,120 square feet and a transit shed capacity of 400,000 square feet.

At the Port of Milwaukee five of six general cargo terminals have been built since 1961. At these five terminals cargo is handled by ship's gear or shore-based heavy lift crane. The other general cargo terminal is much older and rents its cargo-handling equipment as needed.

Montreal, with 48 general cargo facilities, is the largest general cargo port on the Seaway system. Seven terminals provide on-pier, heavy lift equipment, and four rely entirely on ship's gear. There is 598,340 square feet of open storage space available and 3,863,100 square feet of transit shed and warehouse space for storing cargo. There is also a 100,000 square foot, open-ended container storage shed for 750 containers. The containers are handled by a 56,000 pound container crane.

Thunder Bay has three terminals for handling general cargo. At two of these docks the cargo can be handled by ship's gear only. At the third facility, cargo can be handled either by ship's gear or rented cranes. Tonnages and facilities at major general cargo ports on the Great Lakes-Seaway are shown in Table C9-41. References 17 and 53 give further information on major general cargo ports.

TABLE C9-41 Major General Cargo Shipping or Receiving Ports, 1970 (Thousands of Short Tons)

	Facilities	Total	Foreign		Domestic		
			Overseas	Canadian	Coastwise	Lakewise	Internal
U.S. Receiving Ports							
Port of Chicago	11	6,390	1,486	514	16	480	3,894
Port of Detroit	4	3,347	1,645	595	73	1,010	24
Milwaukee, Wis.	6	1,909	267	106	---	1,531	5
Cleveland, Ohio	6	993	521	82	---	384	6
Toledo, Ohio	4	808	334	152	---	281	41
Duluth-Superior	3	761	56	34	---	671	---
Total		14,208	4,309	1,483	89	4,357	3,970
Percent of Total		100%	30%	10%	1%	31%	28%
U.S. Shipping Ports							
Port of Chicago	11	3,219	1,383	168	58	291	1,319
Milwaukee, Wis.	6	1,152	232	---	---	920	---
Port of Detroit	4	1,140	741	5	2	344	48
Cleveland, Ohio	6	869	211	59	23	576	---
Duluth-Superior	3	506	426	14	---	66	---
Toledo, Ohio	4	408	76	64	---	256	12
Total		7,294	3,069	310	83	2,453	1,379
Percent of Total		100%	42%	4%	1%	34%	19%

	Facilities	Total	Foreign		Domestic
			U.S.	Overseas	Receipts or Shipments
Canadian Receiving Ports					
Montreal	48	3,587	2,622	---	965
Toronto	8	1,810	425	586	799
Thunder Bay	5	1,102	81	16	1,005
Hamilton	4	886	337	280	269
Total		7,385	3,465	882	3,038
Percent of Total		100%	47%	12%	41%
Canadian Shipping Ports					
Montreal	48	3,522	2,667	---	855
Thunder Bay	5	927	213	220	494
Hamilton	4	799	37	324	438
Toronto	8	272	6	263	3
Total		5,520	2,923	807	1,790
Percent of Total		100%	53%	15%	32%

NOTE: Includes all commodities except Petroleum, Iron Ore, Grain, Coal, and Limestone.

SOURCES: Waterborne Commerce of the United States, Part 3, Waterways & Harbors, Great Lakes, 1970.
Statistics Canada, Shipping Report Part II, International Seaborne Shipping, 1970.
Statistics Canada, Shipping Report Part III, Coastwise Shipping, 1970.

3.2 Prospective Waterborne Commerce

3.2.1 Methodology

3.2.1.1 Iron Ore, Limestone, and Coal

The latest estimates of potential Great Lakes traffic in iron ore, bituminous coal, and limestone were made for the 50-year period 1970 to 2020 for the Great Lakes Water Levels Study. These three commodities comprise approximately 80 to 85 percent of the total tonnage handled at U.S. Great Lakes ports. Traffic estimates are based on the following assumptions:

(1) Improvements to channels, locks, and harbors will be made during the project period if and when they are required to accommodate the projected traffic, but such improvements will not include an increase in the present controlling depth of the system, which is 27 feet.

(2) There will be no radical changes in the present general pattern of traffic.

(3) By 1995 all harbors shipping or receiving a significant volume of one or more of the four bulk commodities analyzed will have been deepened to 27 feet.

(4) By 1995, additional 1200 by 110 foot locks will be in operation on the Seaway and Welland Canal.

In developing the shipment estimates for each of the three mineral commodities, consideration was given to:

(1) past and anticipated demand requirements of consuming industries in areas having access to Great Lakes transportation

(2) the present and future production capability of suppliers

(3) resource availability in the Great Lakes Region

Quantities were estimated by standard statistical methods using shipment data collected by various United States and Canadian agencies including the U.S. Bureau of Mines,[1] the U.S. Army Corps of Engineers,[48] and the Canadian Ministry of Transport.[7, 32] Projected traffic distribution patterns for U.S. Great Lakes shipments of bituminous coal, iron ore, limestone, and grain were developed from waterborne commerce data obtained by the U.S. Army Corps of Engineers. Tonnages for each type of U.S. Great Lakes traffic (lakewise, export, and import) over each of 25 different origin and destination combinations, were recorded by commodity and by years for the period 1956 to 1964. A computer program written to process the data calculated the annual percentages of each commodity carried over each route as percentages of each annual total commodity movement.

The proportional distribution for the base years 1956 to 1964 were projected to year 1995 by regression analysis (best fit—least square line). The proportions projected for 1995 over each of the traffic routes were normalized to 100 percent for each category (lakewise, export, and import).

Traffic distribution patterns for Canadian coastwise shipments were developed separately in a special study. Separate forecasts for each traffic route were made.

3.2.1.2 Grain

Estimates of prospective grain traffic developed in the Grain Traffic Analysis,[43] which accompanied the Great Lakes Harbors Study,[42] are used here. Eight kinds of grain were included in the study: wheat, corn, barley, rye, oats, grain sorghums, soybeans, and flaxseed.

The projections of potential waterborne grain commerce were developed using the following assumptions:

(1) There will be no major wars or national economic depressions.

(2) Depths of the connecting channels and principal U.S. Great Lakes harbors will permit drafts commensurate with the controlling depth of the 27-foot St. Lawrence Seaway.

(3) Canals and waterways between Lakes Erie and Ontario and in the St. Lawrence River will be adequate to handle the estimated traffic potentials.

(4) All other factors being equal, grain will move from producing areas to foreign and domestic areas of consumption over the most economical routes.

Sources of data for grain traffic include reports by the Interstate Commerce Commission, the Department of Agriculture, the Bureau of the Census, and the Corps of Engineers.

A combination of methods was used to derive projections of future grain exports from the Great Lakes tributary area. A shift analysis based on the present level of U.S. and Great Lakes exports and grain sales from farms combined with other long-range variables was used to establish the future potential for grain exports from Great Lakes ports via the St. Lawrence Seaway.

Two variations of the shift analysis were used in the study. The first, called the proportional shift, was based on the grain exports from Great Lakes ports in 1962. For this the percentages of the 1962 national export total for each type of grain according to destination were compiled and applied to national grain export projections for 1965, 1980, and 2015. This analysis assumes that future Great Lakes ports grain exports will increase in direct proportion to the 1962 national distribution level. The results were used as a bottom limit of future Great Lakes grain export potential.

To estimate the amount of potential exportable grain that is most economically shipped through the Seaway from the Great Lakes tributary area, the present percentages of grain sales from farms within a 15-State Great Lakes area were applied to the national grain export projections to obtain an estimate of total exports generated within the area. The geographical contours of transportation cost advantage to European, Mediterranean, and Latin American countries via the Great Lakes and St. Lawrence Seaway were then used to determine the amount of exports generated within the 15-State area that are best sent via the Seaway route.

The proportional shift analysis and the analysis of exports generated through grain sales resulted in a low and high level estimate of future Great Lakes ports grain exports. To determine the level of future grain exports from Great Lakes ports, it was necessary to consider several other factors, including the long-range trend of grain production and sales from farms within the area. A second factor is the location of the Great Lakes ports in relation to the major foreign area markets. Other considerations examined for each foreign area were variations in population growth rates, increases in standard of living, and individual country dietary habits.

Future traffic estimates contained in the Grain Traffic Analysis[43] were interpolated to find the traffic in 2000 and extended graphically to determine the 2020 traffic.

3.2.1.3 Overseas General Cargo

The estimates developed in the Great Lakes-Overseas General Cargo Traffic Analysis[44] to accompany the Great Lakes Harbors Study[42] were interpolated and extrapolated to the planning periods 1980, 2000, and 2020 for use in this report. The methodology used in the General Cargo Analysis is described below.

A special study of origins and destinations of foreign waterborne commerce in the United States determined that 25 percent of the U.S. waterborne foreign trade was generated in the 19-State area served by Great Lakes ports. This area encompasses 36 percent of the nation's population, 44 percent of the U.S. value added by manufacture, and 50 percent of the value of farm products sold in the U.S. The foreign trade data further revealed which of these Great Lakes areas supplied which overseas foreign areas. Also, the data were adjusted for institutional and other factors, including the closed Great Lakes navigation season during the winter months. The result revealed that approximately 7 percent of the nation's total general cargo foreign trade is available for shipment via U.S. Great Lakes harbors. Analysis of the commodities in overseas general cargo foreign trade indicated that the foreign overseas trade generated in the Great Lakes tributary area would keep pace with the national production rate for those commodities.

The estimate of Canadian general cargo traffic by 1980 presented in the report "St. Lawrence Seaway Tolls and Traffic Analysis and Recommendations" by J. Kates and Associates (1965)[22] is used here. Estimates for planning periods 2000 and 2020 are obtained by plotting the Kates estimate of total Seaway traffic for 1980, 1990, 2000, and 2010, and extrapolating to 2020. Then the estimate of total traffic in 2000 and 2020 is multiplied by the ratio of Canadian general cargo to total Seaway traffic in 1980 to obtain the volume of general cargo traffic.

Several harbors have already handled general cargo traffic equal to or greater than the estimates found by the above methods. It is too early to determine whether these are short-term fluctuations or long-term trends. The recent origin-destination study of U.S. overseas traffic will allow updating of that traffic estimate.[50] New information on both U.S. and Canadian traffic will be included in this report as available.

3.2.1.4 Extension of the Navigation Season

Extension of the navigation season on the Great Lakes would allow more bulk materials and general cargo to be shipped via the Great Lakes. Estimates of shipments on the Great

Lakes would be increased by approximately the tonnages shown in Table C9-87. An additional 25 million tons would move via the Lakes by 2000, including 7 million tons of iron ore, 3 million tons of stone, 2 million tons of coal, 3 million tons of grain, 2 million tons of general cargo, and 8 million tons of other cargo.

3.2.2 Iron Ore

The sources of iron ore for the United States steel industry have changed in the past 20 years, beginning with the inability of the natural iron ore mines in Michigan, Minnesota, and Wisconsin to furnish an adequate long-term ore supply. This led to the discovery and development of new reserves of higher grade ore in Canada and the partial replacement of the upper Great Lakes region as the primary ore source. However, with the advent of ore pellets, the upper Great Lakes region again became competitive to the extent that the University of Minnesota School of Mines forecasts shipment of as many as 75 million tons of iron ore (65 of pellets and 10 of natural ore and concentrate) in 1975 from the region. In fact, the most productive iron ore region in the world is now the very old (Precambrian) strata surrounding Lake Superior in both the United States and Canada.

The Bureau of Mines and the University of Minnesota studies[1] on future U.S. iron ore demand indicate an expected annual growth rate of approximately two percent based on iron units. The Bureau of Mines estimated the average grade of iron ore for blast furnace feed will increase from 57 percent in iron content in 1967 to 60 percent in 1970, 70 percent in 1985, and 80 percent in the year 2000. This increase in grade is expected to result from gradual conversion to prereduced agglomerates and pellets for producing pig iron. Because less ore will be required as grade increases, transportation costs will be less. Consequently the productivity of the furnaces will increase. After the projected iron-unit requirements are adjusted to reflect the expected increase in iron content, the ore tonnage requirements indicate there will be an average annual growth rate of 1.5 percent for the projected period.

Canadian ore deposits are located in the Canadian shield, particularly in western Ontario and in the Knob Lake-Schefferville district in the eastern part of the shield between Quebec and Labrador, approximately 360 miles north of the Gulf of St. Lawrence.

The U.S. Bureau of Mines[1] has indicated U.S. iron ore reserves are adequate to meet the projected demands for at least 100 years if the price of ore increases moderately or if technology reduces the costs of mining and beneficiation.[1] Total iron ore resources in the United States have been estimated at approximately 111 billion tons. Ninety percent of these resources are located in the Lake Superior region principally in the form of taconite, which requires beneficiation to make it acceptable for blast furnace use. It is estimated that by 1980, all iron ore shipped from western Lake Superior will be in the form of pellets (Appendix 5, *Mineral Resources*).

The United States minable iron ore reserves, estimated by the Bureau of Mines at varying price levels,[1] are shown in Table C9-42. The figures, based on 1966 costs and technology, indicate the amount of usable iron ore that may be produced at the indicated price levels. The apparent average mine price is $12 per long ton, and the lowest price limit at which most domestic mines can operate without subsidy is estimated at $9 per long ton.[1] Under 1970 conditions approximately 10 billion short tons of domestic ore is considered economically minable. Nine billion short tons of this ore is in the Lake Superior region adjacent to the Great Lakes waterway.

Iron ore shipments by all modes of transportation were analyzed to determine what percentage of the total annual production was carried on the Great Lakes waterway system. During the nine-year period studied (1956 to 1964), the percentage of lake shipments to total production ranged from 87 to 93 percent. The arithmetic average was 91 percent. A regression analysis showed that 91 percent of

TABLE C9-42 Apparent U.S. Minable Reserves of Iron Ore (Millions of Short Tons)

Region	Iron Ore Prices Per Short Ton $12	$14	$16
Northeastern	150	200	300
Southeastern	250	550	7,000
Lake Superior	9,000	11,000	100,000
Central and Gulf	150	650	700
Western	450	1,000	3,000
Total	10,000	13,500	111,000

production was shipped on the Lakes in the base year 1960. It is not expected that patterns and methods of lake shipment from U.S. origins will change enough by 1995 to cause any long-term change in the percentage of lake shipments to total production.

Imports of iron ore handled on the Great Lakes have accounted in recent years for approximately 20 percent of the total Great Lakes iron ore commerce. Principally from Canadian sources, these imports are expected to remain at this same percentage level throughout the projection period. Estimates made by Canadian authorities also agree with this percentage.

Iron ore production from States bordering the Great Lakes will increase at approximately the same rate as the expected demand. Table C9-44 shows the base used for projecting ore production from these States and represents the modified arithmetic average of total annual production from 1955 to 1965. A regression analysis of the Minnesota production data, representing the largest percentage of total production, indicated the computed value for 1960 was three percent less than the arithmetic average. The arithmetic average was reduced slightly. Because of the much smaller difference for the other States, no adjustment of their production figures was required.

In Appendix 5, *Mineral Resources*, the future production of iron ore in the United States portion of the Great Lakes Basin is estimated as shown in Table C9-43. This is approximately 80 percent of the total usable ore produced in the five border States shown in Table C9-44.

In view of the tremendous annual production, it may be questioned how long the reserves will last. Economic geologists indicate that there is enough iron ore on earth to last at least 200 years at the current rate of consumption. Two-thirds of these reserves are in the western hemisphere, primarily in the United States and Brazil although Canada and Cuba also have notable deposits. Two-thirds of North American ore comes from the Great Lakes ranges in Michigan, Wisconsin, and Minnesota. The 100-mile long Mesabi range is estimated to contain approximately 70 billion tons of low grade material (taconite), which is being used in concentration (pelletizing) processes by several large companies.

Table C9-45 shows the projected iron ore shipments. The projected traffic distribution pattern for 1995 iron ore shipments on the Lakes is shown on Table C9-46. Tables C9-47,

TABLE C9-44 Iron Ore Production in Base Year (1960) in States Bordering the Great Lakes (Millions of Short Tons)

Production Source	1960	1969
Michigan	12.5	15.0
Minnesota	57.1	61.9
New York	2.8	4.2[a]
Pennsylvania	1.5	--
Wisconsin	1.2	--
Total	75.1	81.1

[a]Includes both New York and Pennsylvania.

TABLE C9-43 Great Lakes Iron Ore Production

	Great Lakes Basin Total		Planning Subarea[a]					
			1.0		2.0		5.0	
Year	Long Tons	Short Tons	Long Tons	Short Tons	Long Tons	Short Tons	Long Tons	Short Tons
1968	56,636	63,500	52,000	58,250	3,449	3,860	1,187	1,330
1980	65,550	73,500	61,600	69,000	2,500	2,800	1,450	1,620
2000	90,490	101,200	84,700	95,000	3,800	4,250	1,990	2,230
2020	124,740	139,700	116,400	130,400	5,600	6,300	2,740	3,100
1968 to 2020	4,431,200	4,960,000	4,149,600	4,650,000	184,000	206,000	97,600	110,600

[a]No iron ore has been or is expected to be produced in planning subareas 3.0 and 4.0.

C9–48, and C9–49 show the projected average distances of the U.S. traffic routes, the round-trip hours for the Canadian traffic routes, and the projected round-trip time factor for the vessels handling the cargo. These tables were developed for the Great Lakes Water Levels Study. Figure C9–14 shows the low, medium, and high estimates of prospective traffic.

Figure C9–13 represents the traffic flow of iron based on the projected shipment quantities and traffic distribution pattern for 1995. Because the present sources and markets for iron ore are not expected to change radically, the 1995 general traffic pattern follows closely that of today. As shown on the flow chart and in Table C9–46, the major movement of iron ore is from Planning Subareas, 1.1 and 2.4 to 2.2, 4.1 and 4.3.

TABLE C9–45 Projected Great Lakes Iron Ore Production and Shipments (Millions of Net Tons)

	Base Year 1960	1970[a]	1975	1980	1985	1990	1995	2000	2020
U.S. Production									
High[b]	75.1	81.9	100.0	110.3	120.6	134.5	147.4	164.6	297.5
Medium[c]	75.1	81.9	93.9	101.2	109.0	117.4	126.5	135.0	182.0
Low[d]	75.1	81.9	80.2	81.3	83.7	86.3	88.2	91.4	123.2
Shipments									
Medium									
U.S. Lakewise	68.5	72.2	82.1	88.4	95.3	102.7	110.7	119.2	160.6
U.S. Export	5.0	2.5	5.1	5.0	4.9	4.8	4.8	4.8	4.8
U.S. Import	8.1	16.4	24.0	25.3	26.9	28.4	30.1	31.9	44.0
Canadian Coastwise[e]	___	3.1	4.0	5.1	6.1	7.1	8.1	8.1	11.6
Total	81.6	94.2	115.2	123.8	133.2	143.0	153.7	164.0[f]	221.0[f]
High[f]	81.6	106.4	121.0	134.0	146.0	163.0	179.0	200.0	360.0
Low[f]	81.6	91.0	96.0	98.6	102.0	105.0	107.0	111.0	150.0

[a]Actual 1970 production.

[b]Judgment projection based on historical requirement for iron content in the period 1960 to 1970 which equaled about a 3% annual increase in iron content requirements. Same projected percent of iron content per ton of production as Bureau of Mines Information Circular 8461.[1]

[c]Data to 1995 from Bureau of Mines Information Circular 8461. Data for 2000 and 2020 based on growth rate of about 1.5%.

[d]Judgment projection based on rate of growth slightly higher than OBERS (Bureau of Census, Series C, from publication P 25 no. 381) projected rate of 1.3%. This study indicated a future U.S. iron ore demand to equal an expected annual growth rate of approximately 1.5% based on iron units. Same projected percent of iron content per ton of production as Bureau of Mines Information Circular 8461.

[e]The 1995 estimate provided by the Ministry of Transport (Canada). Other values were interpolated between 1970 and 1995. Estimates for 2000 and 2020 were obtained by subtracting the estimated U.S. shipments from estimated total shipments.

[f]Estimated using 1995 ratio of production to total shipments, medium projection.

TABLE C9–46 Projected Iron Ore Traffic Distribution Pattern in 1995 (Percent of Respective Traffic Type)

		Destination				
Type of Traffic	Origin Lake	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
U.S. Lakewise	Superior	--	33.15	--	57.36	--
U.S. Export, Canadian Import	Superior	--	--	--	--	100.00
U.S. Import, Canadian Éxport	Superior	--	10.60	--	5.70	--
Canadian Coastwise	Superior	19.80	--	--	4.90	24.70
U.S. Lakewise	Michigan	--	4.78	--	4.69	--
U.S. Import, Canadian Export	Huron	--	1.70	--	6.60	--
U.S. Import, Canadian Export	Ontario	--	17.60	--	57.80	--
Canadian Coastwise	and/or St. Lawrence	--	--	--	--	50.60

TABLE C9–47 Mileages of Projected Iron Ore Shipments in United States Fleet in 1995

		Destination				
Type of Shipment	Origin Lake	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
Lakewise	Superior	292	797	458	792	---
Export	Superior	316	---	---	935	971
Lakewise	Michigan	---	276	---	507	---
Export	Michigan	197	---	---	651	735
Import	Michigan	699	---	474	---	1172
Lakewise	Erie	---	---	---	430	---
Export	Erie	486	---	---	---	292
Import	Erie	703	---	304	---	416

TABLE C9–48 Round Trip Hours of Projected Iron Ore Shipments in Canadian Fleet in 1995

		Destination				
Type of Shipment	Origin Lake	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Coastwise	Superior	72	--	--	127	220
Exports	Superior	--	176	--	122	--
Imports	Superior	--	--	--	--	236
Exports	Huron	--	142	--	64	--
Exports	Ontario	--	--	--	77	--
Coastwise	St. Lawrence	--	--	--	--	173
Exports	St. Lawrence	--	217	--	161	--

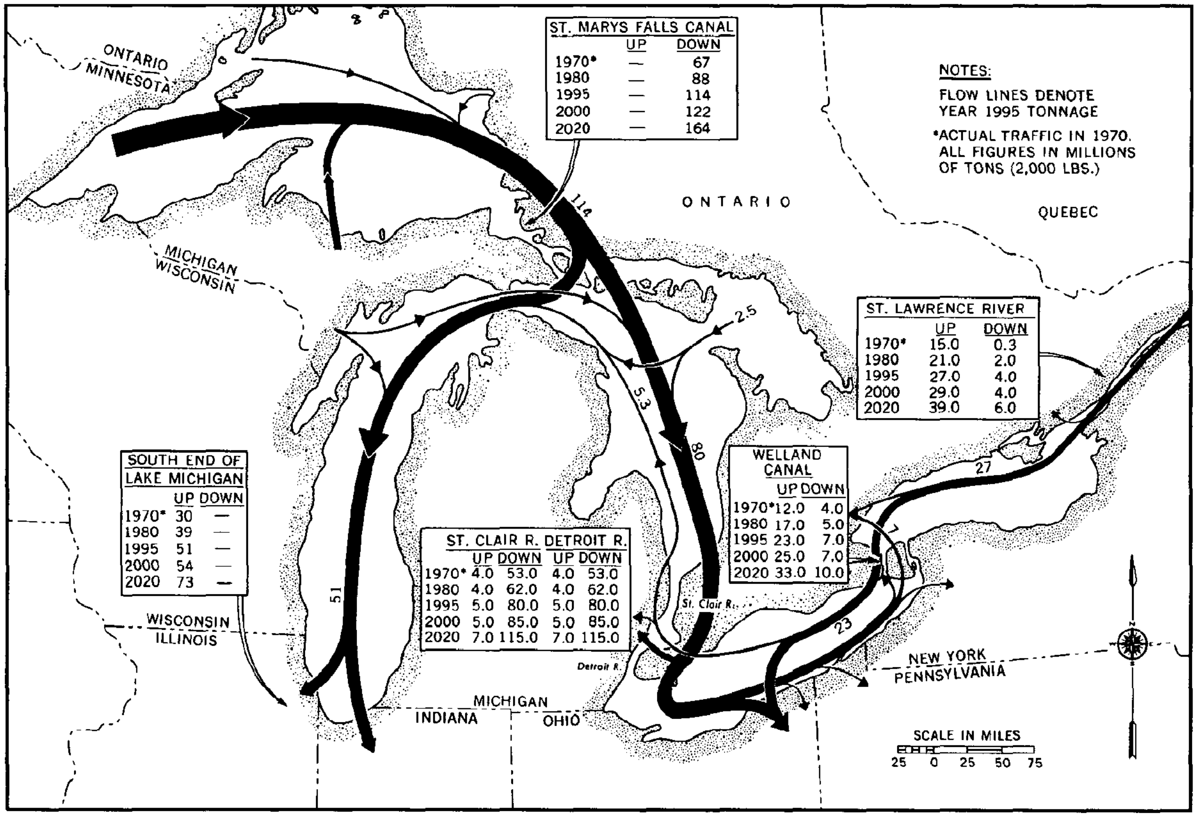


FIGURE C9–13 Projected Iron Ore Traffic Flow, 1995

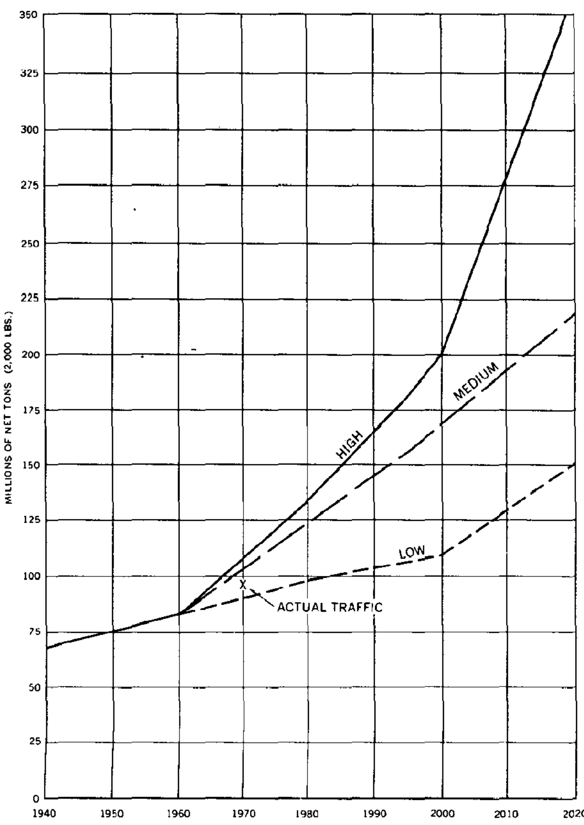


FIGURE C9–14 Iron Ore Traffic on the Great Lakes-St. Lawrence Seaway

TABLE C9–49 Round Trip Time Factor of Loaded-Trip Time for Iron Ore in 1995

Vessel Class	Overall Length (feet)	Iron Ore Shipments
5	600–649	180% + 16 hrs
6	650–699	200% + 16 hrs
7	700–730	200% + 16 hrs
8	731–849	200% + 10 hrs
9	850–949	200% + 12 hrs
10	950–1000	200% + 14 hrs

3.2.3 Bituminous Coal

Coal-bearing rocks underlie approximately 14 percent of the continental United States. Coal reserves have been identified in 34 States.[1] The bituminous coal resources contributing to the coal commerce of the Great Lakes are in the States bordering Lakes Ontario, Erie, and Michigan (Table C9–50). These States are close enough to the Lakes that transportation costs to the lake harbors are reasonable. Approximately 90 percent of the total U.S. bituminous coal production came from these States from 1957 to 1966. During this period approximately 10 percent of the total tonnage produced from these States was

TABLE C9-50 Estimated Bituminous Coal Reserves in Principal States Contributing to Coal Commerce of the Great Lakes (Millions of Net Tons)

State	Estimated Original Reserves	Depleted Reserves[a]	Remaining Reserves[a]	Recoverable Reserves[a] Assuming 50% Recovery
Illinois	137,329	948	136,381	68,190
Indiana	37,293	2,296	34,997	17,499
Kentucky	72,318	5,292	67,026	33,513
Ohio	46,488	4,104	42,384	21,192
Pennsylvania	75,093	16,566	58,527	29,263
Tennessee	1,912	12	1,900	950
Virginia	11,696	1,544	10,152	5,076
West Virginia	116,618	12,738	103,880	51,940
Total	498,747	43,500	455,247	227,623

[a]January 1, 1960 date used.

transported on the Great Lakes. Coal production from these States is expected to follow closely the growth in national energy consumption. Bureau of Mines forecasts estimate an energy consumption growth rate of 3.2 percent annually for the period 1966 to 1980. Consumption estimates of bituminous coal have been forecast for this period at an average annual growth rate of 3.0 percent. The recoverable bituminous coal reserves from these States are apparently adequate to meet the nation's projected requirements for at least the next 100 years. Coal accounts for 88 percent; petroleum, 3 percent; oil shale, 6 percent; and natural gas, 3 percent of the world's reserves of fossil fuels.

In this study, a modification of these two nationwide growth rates, 3.2 percent and 3.0 percent, was used in projecting bituminous coal production for those areas contributing to bituminous coal commerce on the Great Lakes. An annual growth rate of 3.1 percent was set for bituminous coal production until the year 1980. For the period beyond 1980 the annual growth rate was reduced to 2.5 percent. This reduction compensates for the decrease in coal output because of nuclear energy, while providing for some new coal requirements as technology for coal liquefaction and gasification is perfected and used. It also takes into consideration diminishing gas and oil supplies. Any large increase in nuclear energy for electric power generation will depend on the successful development of an efficient breeder reactor.

For a variety of reasons, projected coal output is not expected to increase at a uniform rate throughout all States contributing to Great Lakes commerce. In Illinois, where a high nuclear energy growth rate is projected by the Federal Power Commission, the growth rate of coal production has been estimated to be less than that for other areas of the Great Lakes Region. In Pennsylvania data developed for the Susquehanna River Basin Mineral Economic Survey in 1964 by the Bureau of Mines indicate a negative growth rate for anthracitic coal and a relatively slow growth rate for output of bituminous coal in the eastern part of the State. Data from the Projective Economic Study of the Ohio River Basin, prepared in 1964 by Arthur D. Little, Inc.,[23] for the Corps of Engineers, indicate a higher growth rate for bituminous coal up to the year 2000 in western Pennsylvania, and in Ohio and Indiana. All of these factors were considered in estimating future coal production from areas contributing to commerce on the Great Lakes for base year 1960.

Bituminous coal shipments from districts contributing to coal commerce on the Great Lakes were analyzed to determine what percentage of the total annual production from each district was being transported on the Great Lakes. In 1960, the base year used for projecting future shipments, Bureau of Mines data indicated that 11.91 percent of the total production from the districts listed in Table C9–51 was shipped on the Great Lakes. A time trend analysis, using the percentage of lake shipments to total production for selected years from 1957 to 1966, indicated an average annual decline of approximately 1.4 percent. This trend was applied to the 11.91 percent established for the base year 1960 and was used as the basis for projecting the shipments given in Table C9–52. In view of the uncertain effects of nuclear power and new technology on future coal consumption, the estimated Great Lakes shipments of coal in 1995 are assumed to hold at that level through 2020.

The projected traffic distribution pattern for 1995 bituminous coal shipments on the Lakes is shown in Table C9–53. Tables C9–54 and C9–55 show the projected average distance of U.S. traffic routes for bituminous coal shipments and round-trip time in hours for the Canadian traffic routes. Round-trip time factors of loaded-trip times for vessels projected to handle this commerce are shown in Table C9–56. Figure C9–16 shows the low, medium, and high estimates of prospective traffic. Figure C9–15 represents the traffic flow of bituminous coal based on the projected shipment quantities and traffic distribution pattern for 1995.

As shown on the flow chart and in Table C9–33, the major U.S. shipping harbors are Port of Chicago (Planning Subarea 2.2), Toledo and Sandusky (Planning Subarea 4.2), and

TABLE C9–51 Bituminous Coal Production and Great Lakes Shipments, 1960

District	States in Districts	Production[a]	Great Lakes Shipments[a]	% Production Shipped on Great Lakes
1	Eastern Pennsylvania, Maryland, West Virginia	29,553	1,386	4.69
2	Western Pennsylvania	37,027	2,958	7.99
3 & 6	West Virginia	40,544	3,707	9.14
4	Ohio	33,957	6,643	19.56
7	West Virginia, Virginia	33,661	4,763	14.15
8	West Virginia, Tennessee, Virginia, Kentucky, North Carolina	112,666	19,709	17.49
9	Western Kentucky	30,587	2,726	8.91
10	Illinois	45,977	2,887	6.28
11	Indiana	15,538	407	2.62
	Total	379,510	45,186	11.91

[a]Thousand net tons.

TABLE C9–52 Projected Great Lakes Coal Production (Millions of Net Tons)

	Base Year 1960	1970	1975	1980	1985	1990	1995	2000	2020
				U. S. Production					
High[a]	380	597	745	935	1170	1463	1835	1835	1835
Medium[b]	380	516	600	700	792	896	1014	1014	1014
Low[c]	380	430	458	487	518	552	587	587	587
				Shipments					
Medium:[b]									
U.S.Lakewise	36	42	45	47	49	50	52	52	52
U.S.Export	9	11	13	15	17	19	22	22	22
U.S.Import	0	0	0	0	0	0	0	0	0
Canadian Coastwise	0	0	0	0	0	0	0	0	0
Total	45	53	58	62	66	69	74	74	74
High:[d]	45	61	72	83	97	113	134	134	134
Low:[d]	45	44	44	43	43	43	43	43	43

[a]Indicated projected annual rate of increase of 4.6% from Bureau of Mines 1969 Minerals Yearbook, Volume I-II page 22.

[b]Data to 1995 from Bureau of Mines Information Circular 8461.[1] In view of the uncertain effects of nuclear power and new technology on future coal consumption, the estimated Great Lakes production and shipments of coal in 1995 are assumed to hold at that level through 2020.

[c]Indicated projected annual rate of increase of 1.25% from Landsberg, Hans H., Fischman, Leonard L., and Fisher, Joseph I., Resources in America's Future, the Johns Hopkins Press, Baltimore: 1963. The medium projection of total consumption including exports on page 854 for the years 1960–2000 was used.

[d]Estimated using the same ratio of production to total shipments as Bureau of Mines Information Circular 8461. Shipments after 1995 held at 1995 level.

TABLE C9–53 Projected Bituminous Coal Traffic Distribution Pattern in 1995 (Percent of Respective Traffic Types)

Type of Traffic	Origin Lake	Destination: Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
U.S. Lakewise	Michigan	---	17.82	1.16	---	---
U.S. Lakewise	Erie	8.98	5.66	31.67	34.71	---
U.S. Export, Canadian Import	Erie	14.00	---	15.40	19.50	49.80
U.S. Export, Canadian Import	Ontario and/or St. Lawrence	---	---	---	---	1.30

TABLE C9–54 Mileages of Projected Bituminous Coal Shipments in United States Fleet in 1995

Type of Shipment	Origin Lake	Destination: Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
Lakewise	Superior	---	---	---	766	---
Export	Superior	166	---	---	---	---
Lakewise	Michigan	743	126	533	623	---
Export	Michigan	645	---	357	---	---
Lakewise	Erie	717	628	184	74	---
Export	Erie	396	---	239	94	237
Lakewise	Ontario	---	---	---	---	41
Export	Ontario	---	---	---	---	117

TABLE C9–55 Round Trip Hours of Projected Coal Shipments in Canadian Fleet in 1995

Type of Shipment	Origin Lake	Destination: Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Imports	Erie	87	---	63	46	100
Imports	Ontario	---	---	---	---	52

TABLE C9–56 Round Trip Time Factor of Loaded-Trip-Time for Bituminous Coal in 1995

Vessel Class	Overall Length (feet)	Bituminous Coal Shipments
4	500–599	125% + 10 hrs
5	600–649	180% + 16 hrs
6	650–699	200% + 16 hrs
7	700–730	200% + 16 hrs

Conneaut (Planning Subarea 4.3). Major U.S. receiving harbors are Duluth-Superior (Planning Subarea 1.1), Green Bay (Planning Subarea 2.1), Milwaukee, Oak Creek, Port of Chicago, and Indiana Harbor (Planning Subarea 2.2), Muskegon (Planning Subarea 2.3), Saginaw River (Planning Subarea 3.2), and Port of Detroit and St. Clair (Planning Subarea 4.2).

3.2.4 Limestone

The future demand for limestone from sources in the Great Lakes area will depend on economic factors that will similarly affect much of our national economy.[1] Limestone demands are tied to the rate of steel output and are subject to changing technology in the composition of blast furnace feed. In 1955,

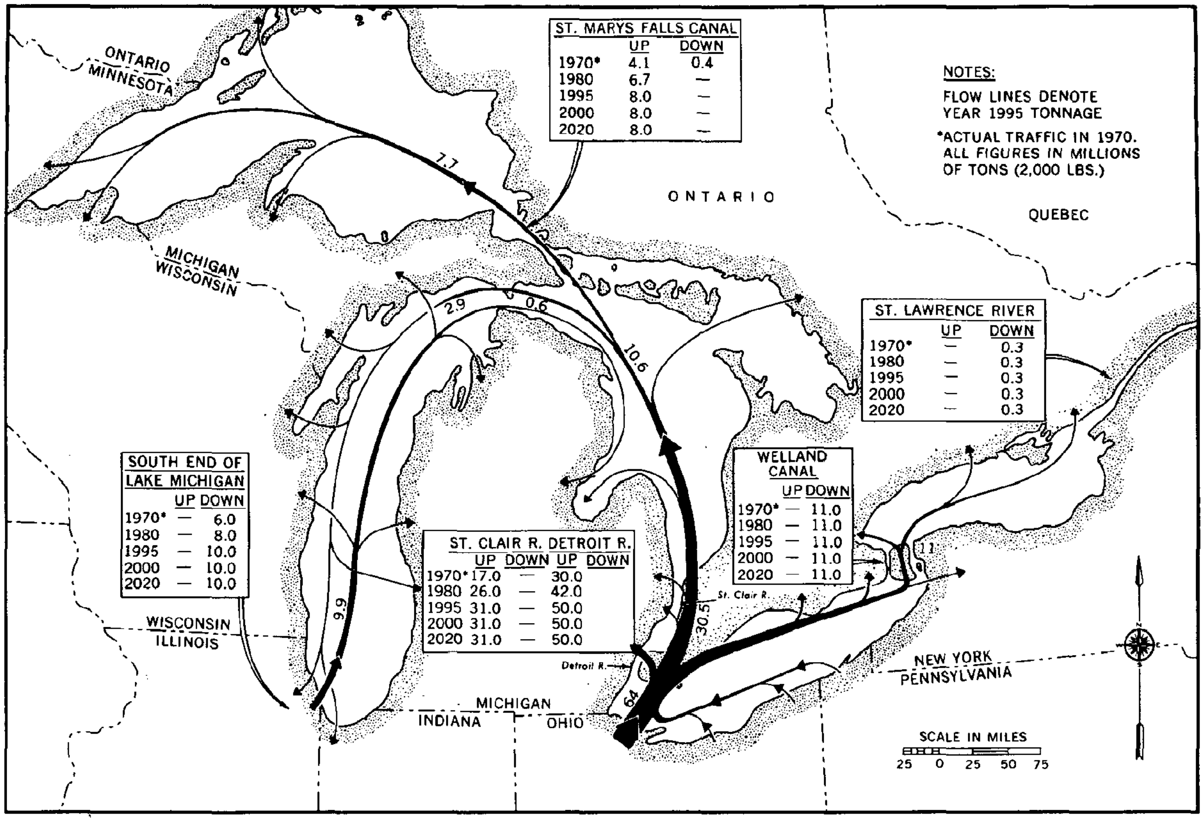


FIGURE C9–15 Projected Bituminous Coal Traffic Flow, 1995

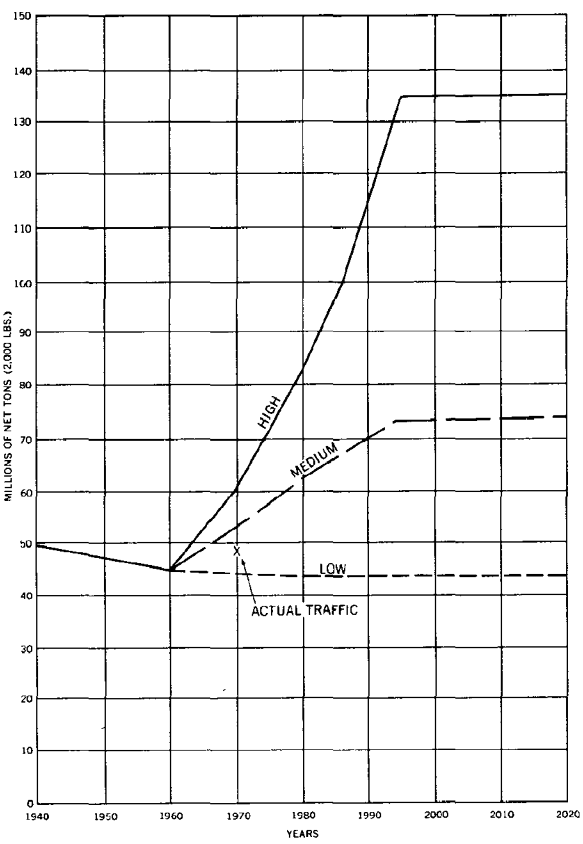


FIGURE C9–16 Coal Traffic on the Great Lakes-St. Lawrence Seaway

0.389 net ton of limestone and dolomite was used to produce one net ton of pig iron. This amount had been reduced to 0.279 net ton by 1965. Present technology indicates that these requirements will be further reduced to approximately 0.270 net ton per ton of pig iron produced. Limestone requirements for construction material will depend on population growth, the growth of the gross material product, road building, and residential, commercial, and industrial construction. Other factors such as the demand for lime and industrial chemicals will have a direct bearing on future limestone requirements from Great Lakes sources.

The State of Michigan historically has been and is forecast to be the principal source of limestone commerce on the Great Lakes. The limestone industry in Michigan is concentrated in a few large companies, which not only operate quarries, but mills, processing plants, ports, and fleets of ships. From 33 to 40 percent of the waterborne limestone shipments have gone to steel mills for use as a fluxing agent. Another 40 percent goes to the construction industry for manufacturing cement and for aggregate used in road and building construction. Approximately 20 percent is

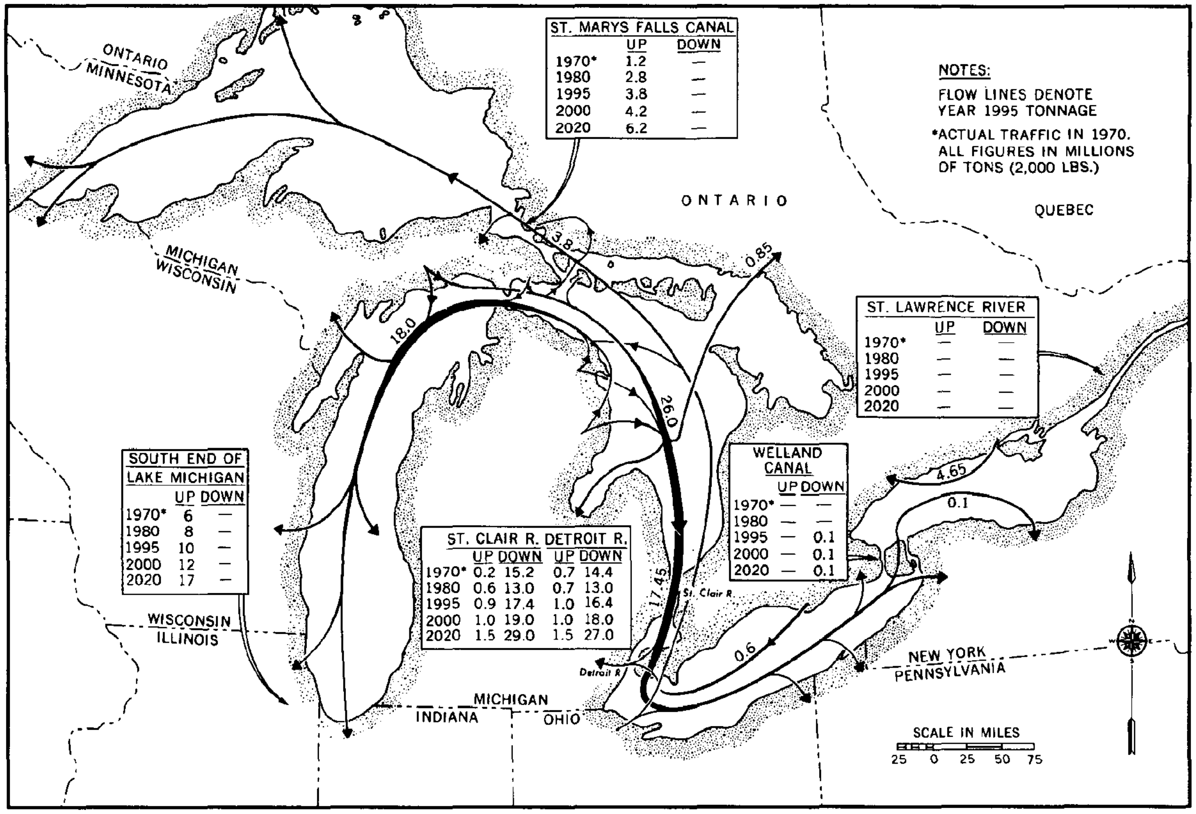


FIGURE C9–17 Projected Limestone Traffic Flow, 1995

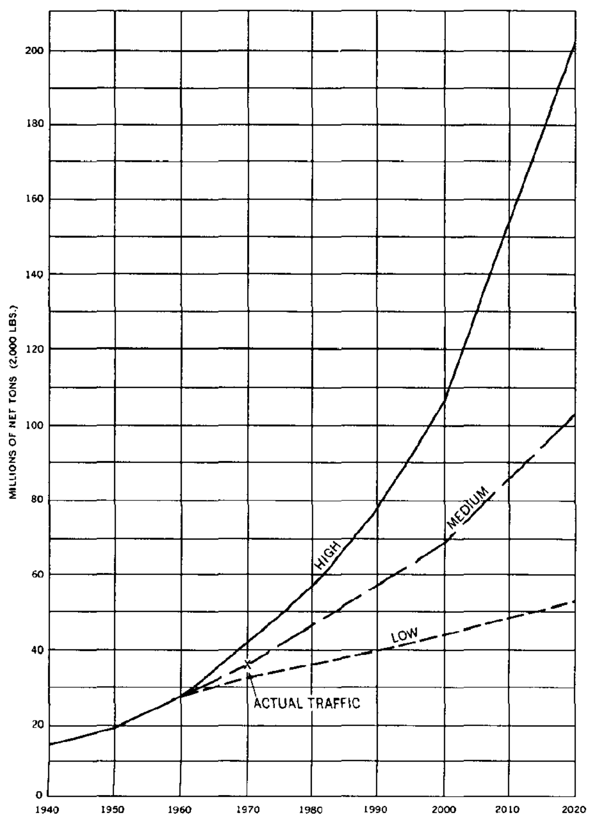


FIGURE C9–18 Limestone Traffic on the Great Lakes-St. Lawrence Seaway

sold to manufacturers of lime and other chemicals and for a variety of miscellaneous uses (e.g., various types of filler and poultry grit). Approximately 2 percent is used as fertilizer.

Limestone reserves near the shores of the Great Lakes are expected to continue to be the principal source of stone commerce on the Great Lakes. The high-bulk, low-unit value of limestone influences the economic utility of a deposit, which must compete with other sources on a delivered-cost basis. The availability and cost of transportation usually determine whether a particular deposit is commercially desirable. Limestone reserves in the Great Lakes area occur near the western end of Lake Erie in Ohio and Michigan, around the northern end of the Lower Peninsula of Michigan, and along the south shore (on Lake Michigan) of the Upper Peninsula of Michigan. Although the limestone reserves in these areas have not been quantitatively estimated, they appear to be extremely large and able to support the present and projected production and shipping requirements for at least 50 years.

Michigan was selected as the source area for future limestone production. Projected production was based in part on the linear trend of Michigan limestone production for the period 1924 to 1964. An annual growth rate, modified to reflect changing blast furnace technology, of approximately 2.8 percent was indicated by this trend. This growth trend was applied to the base year 1960 at a calculated production level of 31.6 million tons, the arithmetic average of production for 1955 through 1965. A regression analysis was also made of Michigan's production for this same 11-year period, and little difference was noted between the computed 1960 base year figure and the arithmetic average. The projected production figures for Michigan are presented in Table C9-57.

Great Lakes shipments from Michigan averaged approximately 84 percent of the State's limestone production from 1955 to 1965. A regression analysis of the relationship between the annual percentage of shipments and production for this period indicates a downward trend at an average annual rate of approximately 0.5 percent. When applied to the 84-percent shipment-to-production rate calculated for 1960, this trend indicates that by 1995 lake shipments from Michigan should

TABLE C9-57 Projected Michigan Limestone Production (Millions of Net Tons)

	Base Year 1960	1970	1975	1980	1985	1990	1995	2000	2020
			U. S. Production						
High[a]	31.6	47	57	69	84	103	125	152	332
Medium[b]	31.6	42	48	55	63	72	83	95	161
Low[c]	31.6	36	38	41	44	47	50	53	67
			Shipments						
Medium:									
U.S.Lakewise	25.63	31.4	34.7	38.3	42.3	46.7	51.6	57.0	84.6
U.S.Export	.84	1.7	2.2	2.8	3.4	3.9	4.4	4.8	7.2
U.S.Import	.12	.5	.8	1.1	1.4	1.7	2.0	2.2	2.3
Canadian Coastwise	2.6	3.2	3.6	4.2	4.6	5.0	5.3	6.0	8.7
Total	29.29	36.8	41.3	46.4	51.7	57.3	63.3	70.0	103.8
High:[d]	29.29	40.9	48.5	57.0	67.0	78.8	91.3	106.8	201.4
Low:[d]	29.29	32.3	34.2	35.9	37.6	39.4	40.8	42.6	51.1

[a] Indicated projected annual rate of increase of 4% from OBERS national aggregate projection of gross national product, 1968-2020. As stated in the Stone Traffic Analysis to accompany Great Lakes Harbor Study, April 1958, "Because of the wide variety of uses of stone, it is considered reasonable to assume that the national production of stone will increase at least as fast as the gross national product."

[b] Data to 1995 from Bureau of Mines Information Circular 8461.[1] Approximately the same rate of increase was extrapolated to 2020.

[c] Indicated projected annual rate of increase of 1.3% from OBERS national aggregate projection of population, 1968-2020. This annual rate would incorporate a variety of reasonable low economic growth assumptions.

[d] Estimated using the same ratio of production to total U. S. shipments as Bureau of Mines Information Circular 8461 extrapolated to 2020. Import and Canadian coastwise held at constant (medium) level.

approximate 70 percent of the State's limestone production. Table C9-58 presents the projected Great Lakes limestone shipments based on the assumption that the State of Michigan will be the principal production source. Lakewise and export quantities have been projected from 26.5 million net tons in 1960 to 62 million net tons by 2000, and to 92 million net tons by 2020, an annual growth rate of approximately 2.1 percent. Applying 2.1 percent growth to the 1995 Canadian coastwise shipments indicates approximately 9 million tons by 2020. The import shipments of limestone to U.S. Great Lakes ports are expected to come solely from Canada. It is expected that they will increase from approximately 0.5 million net tons in 1970 to 2.2 million net tons by 2000 and 3.3 million net tons by 2020. The import and Canadian coastwise shipments were held constant (medium level) for use in the low and high shipment estimates. Figure C9-18 shows the low, medium, and high estimates of prospective traffic.

The projected traffic distribution pattern for 1995 limestone shipments on the Lakes is shown in Table C9-58. Figure C9-17 represents the traffic flow of limestone based on the projected shipment quantities and traffic distribution pattern for 1995.

The projected average distance of the U.S. traffic routes, the round-trip hours for the Canadian traffic routes and the round-trip time for vessels projected to handle this commerce are shown in Tables C9-59, C9-60, and C9-61. As shown in Figure C9-17, limestone is shipped from Planning Subareas 2.4, 3.1, and 4.2 to Planning Subareas 2.2 (southern Lake Michigan ports) and 4.1 (Port of Detroit).

TABLE C9-58 Projected Limestone Traffic Distribution Pattern in 1995 (Percent of Respective Traffic Types)

		Destination				
Type of Traffic	Origin Lake	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
U.S. Lakewise	Superior	---	---	.34	6.99	---
U.S. Lakewise	Michigan	---	14.48	6.44	8.11	---
U.S. Lakewise	Huron	4.47	20.47	8.90	17.88	---
U.S. Export, Canadian Import	Huron	30.70	---	19.30	8.00	---
U.S. Lakewise	Erie	---	---	.03	11.85	.05
U.S. Export, Canadian Import	Erie	3.40	---	19.30	19.30	---
U.S. Import, Canadian Export	Erie	---	---	---	100.00	---
Canadian Coastwise	Erie	---	---	---	11.40	---
Canadian Coastwise	Ontario and/or St. Lawrence	---	---	---	---	88.60

TABLE C9-59 Mileages of Projected Limestone Shipments in United States Fleet in 1995

		Destination				
Type of Shipment	Origin Lake	Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
Lakewise	Superior	315	301	158	452	--
Export	Superior	265	--	213	265	622
Lakewise	Michigan	222	268	279	462	--
Export	Michigan	--	--	285	--	773
Lakewise	Huron	426	364	132	354	--
Export	Huron	104	--	238	333	463
Lakewise	Erie	--	--	129	53	160
Export	Erie	481	--	97	--	--

TABLE C9–60 Round Trip Hours of Projected Limestone Shipments in Canadian Fleet in 1995

Type of Shipment	Origin Lake	Destination Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario
Imports	Huron	52	---	72	67	---
Coastwise	Erie	---	---	---	57	---
Exports	Erie	---	---	---	49	---
Imports	Erie	77	---	47	42	---
Coastwise	Ontario	---	---	---	---	62

TABLE C9–61 Round Trip Time Factor of Loaded-Trip Time for Limestone in 1995

Vessel Class	Overall Length (feet)	Limestone Shipments
4	500–599	125% + 10 hrs
5	600–649	180% + 16 hrs
6	650–699	200% + 16 hrs
7	700–730	200% + 16 hrs
8	731–849	200% + 10 hrs
9	850–949	200% + 12 hrs

3.2.5 Grain

3.2.5.1 General

The estimate of grain traffic in the Grain Traffic Analysis[43] for the Great Lakes Harbors Study[42] for 1965 to 2015 were interpolated and extrapolated to the planning periods of 1980, 2000, and 2020. The estimated movements of grain are described in the following paragraphs.

The three most significant reasons for the changes and the growth prospects of Great Lakes grain traffic are an improved transportation route, an increased overseas market for United States grain, and a strong grain-producing area tributary to U.S. Great Lakes ports. Since 1959 the Seaway depth of 27 feet has accommodated larger ships carrying several times the cargo carried by the smaller ships of the pre-Seaway fleet. Grain exports from the Great Lakes area now move via the Great Lakes-St. Lawrence Seaway direct to overseas areas or to Canadian ports on the lower St. Lawrence River for transshipment overseas. The six Midwest States bordering the Great Lakes produce 37 percent of U.S. grain and in combination with nine additional States served by Great Lakes ports they produce 79 percent of the United States grain.

Present shipping facilities are located almost entirely at Duluth-Superior and Thunder Bay on Lake Superior. These facilities are considered adequate to handle at least twice the current volume of traffic based on experience at coastal ports. The sale of grain to Russia and other countries will increase exports (especially wheat). The increase in wheat production in North Dakota and Minnesota will continue.

3.2.5.2 Future Great Lakes Exports

Exports of grain from U.S. Great Lakes ports, expressed in millions of net tons, increased sharply from 0.9 in 1958 to 3.5 in 1959, the first year of the Seaway, to 6.9 in 1964, and to 9.1 in 1970. These exports are projected to increase further to 10.0 in 1975, 11.0 by 1980, 14.0 by 2000, and to 17.0 by 2020. Total United States grain exports increased from 22.5 million tons in 1958 to approximately 49 million tons in 1964. They are projected to increase to 53 million tons by 1980, 63 million tons by 2000, and 74 million tons by 2020. As percentages of United States total exports, the Great Lakes exports amounted to 3.9 in 1958, 12.8 in 1959, 14.1 in 1964, 16.0 in 1970, and are projected to increase to 20.6 by 1980, 22.2 by 2000, and to 23.0 by 2020. The grain exports will continue to be shipped principally from Lake Superior, Lake Michigan, and Lake Erie.[43]

The individual grains projected to show the greatest export growth, both on the national and Great Lakes ports level, are wheat, corn, and soybeans. These three commodities are projected to account for 86 percent of both U.S. and Great Lakes ports total grain exports in the planning period.

3.2.5.3 Future Lakewise Grain Shipments

Domestic grain shipments via the Seaway to U.S. East Coast destinations have a higher transportation cost than ex-lake grain, i.e., grain shipped by rail out of eastern Great Lakes ports to destinations along the East Coast. Railroads have provided special rates to encourage such movement. Seaway traffic of this kind has not developed. The dominant grain movement of lakewise grain traffic between the U.S. Great Lakes ports is expected to continue to go from the western ports of Lake Superior to the eastern ports on Lake Erie. The total lakewise traffic (in millions of tons) was 3.0 in 1958, 2.3 in 1959, 2.7 in the 1961 to 1963 period, and 2.2 in 1970. Several variables contribute to the conclusion that lakewise grain traffic will assume the national growth rate of slightly more than one-half of one percent per year. This traffic is projected to increase to 3.0 million tons by 1980, 3.4 million tons by 2000, and 3.7 million tons by 2020. The slight decline in lakewise grain traffic in 1959 was due primarily to a decrease in grain receipts at ports on Lake Erie and Lake Ontario. This was because some grain exports traveled via the Seaway rather than via eastern Great Lakes ports and overland to Atlantic Coastal ports for export overseas. Lakewise grain traffic is projected to continue supplying domestic grain markets in northeastern States as it did in pre-Seaway days.

3.2.5.4 Imports from Great Lakes Canada

The decline in grain imports from Canada at U.S. Great Lakes ports is reflected in the total imports of grain from Canada and overseas for the entire United States. Total U.S. imports of wheat, barley, rye, and oats, excluding grain moving in bond, declined from 1.557 million tons between 1948 and 1957 to 0.612 million tons in the 1959 to 1963 period. This represents a decline of 60.7 percent. Imports in 1970 totaled 0.3 million tons.

In addition to the opening of the St. Lawrence Seaway in 1959, other strong variables have affected both Great Lakes ports and total

TABLE C9-62 Projected Great Lakes Grain Shipments[a] (Millions of Net Tons)

Projection	Base Year 1960	Actual 1970	1980	1995	2000	2020
Medium						
United States						
Lakewise	2.4	2.5	3.0	3.3	3.4	3.7
Export	4.0	8.5	11.0	13.1	13.8	16.7
Import	0	0	0	0	0	0
Canadian Coastwise[b]		10.7	11.8	14.3	15.2	18.5
Total		21.7	25.8	30.7	32.4	38.9
High[c]			28.5	36.6[d]	39.3	52.1
Low[c]			24.4	26.6[d]	27.4	31.8

[a]All U.S. traffic projections are based upon projections of Senate Select Committee on National Water Resources, Committee Print No. 12, 86th Congress 2nd Session, with straight-line extrapolation to 2020. Ratios of total production to export and lakewise traffic are from Grain Traffic Analysis,[43] Great Lakes Harbors Study, by the Corps of Engineers.

[b]Canadian coastwise shipments for medium projection for 1995 were estimated by Dominion Bureau of Statistics. Other years were estimated by straight-line growth using 1995 and actual 1967 traffic as controlling points. High and low projections were developed using ratio of U.S. high and low projections to U.S. medium projection.

[c]Estimated using same ratio of shipments to production as medium projection.

[d]Interpolated between 1980 and 2000 projections.

TABLE C9–63 Projected Grain Traffic Distribution Pattern in 1995 (Percent of Respective Traffic Types)

Type of Traffic	Origin Lake	Destination: Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
U.S. Lakewise	Superior	---	---	---	75.39	4.00
U.S. Export, Canadian Import	Superior	---	---	---	---	30.99
U.S. Import, Canadian Export	Superior	---	70.00	---	30.00	---
Canadian Coastwise	Superior	---	---	10.18	5.26	84.56
U.S. Lakewise	Michigan	---	---	---	14.46	---
U.S. Export, Canadian Import	Michigan	---	---	.83	---	42.15
U.S. Import, Canadian Export	Michigan	---	---	---	---	---
Canadian Coastwise	Michigan	---	---	---	---	---
U.S. Lakewise	Erie	---	---	---	4.92	---
U.S. Export, Canadian Import	Erie	---	---	---	.27	25.76
U.S. Import, Canadian Export	Erie	---	---	---	---	---
Canadian Coastwise	Erie	---	---	---	---	---

TABLE C9–64 Projected Deep-Draft Lakewise Shipments and Receipts of Grain at U.S. Great Lakes Harbors, 1980 to 2020, Compared with 1959 to 1963 Actual Average (Thousands of Tons)

Year	Lake Superior Shipments	Lake Superior Receipts	Lake Michigan Shipments	Lake Michigan Receipts	Lakes Huron, Erie and Ontario Shipments	Lakes Huron, Erie and Ontario Receipts	Great Lakes Total Shipments	Great Lakes Total Receipts
1959-63	2,033	7	412	27	111	2,522	2,556	2,556
1980	2,400	10	455	40	145	2,950	3,000	3,000
2000	2,700	10	490	40	170	3,300	3,400	3,400
2020	3,000	10	520	40	200	3,600	3,700	3,700

SOURCE: Corps of Engineers, Waterborne Commerce of the United States, Part 3.[48]

TABLE C9–65 Mileages of Projected Grain Shipments in United States Fleet in 1995

Type of Shipment	Origin Lake	Destination: Lake Superior	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario and/or St. Lawrence
Lakewise	Superior	--	808	--	986	1,025
Export	Superior	--	--	--	--	1,334
Lakewise	Michigan	--	--	--	893	--
Export	Michigan	--	--	535	--	1,200
Import	Michigan	686	--	--	--	--
Lakewise	Erie	--	--	--	254	--
Export	Erie	--	--	--	143	561
Import	Erie	864	--	--	--	--

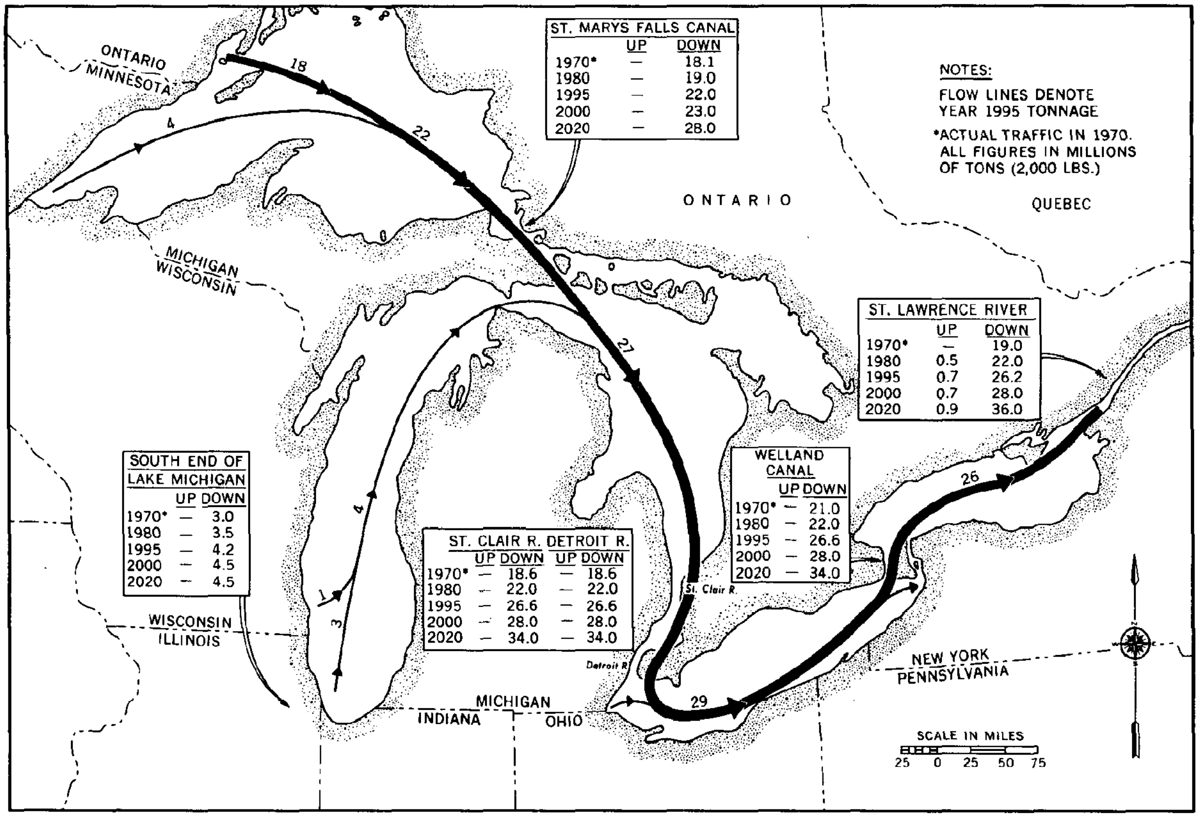


FIGURE C9–19 Projected Grain Traffic Flow, 1995

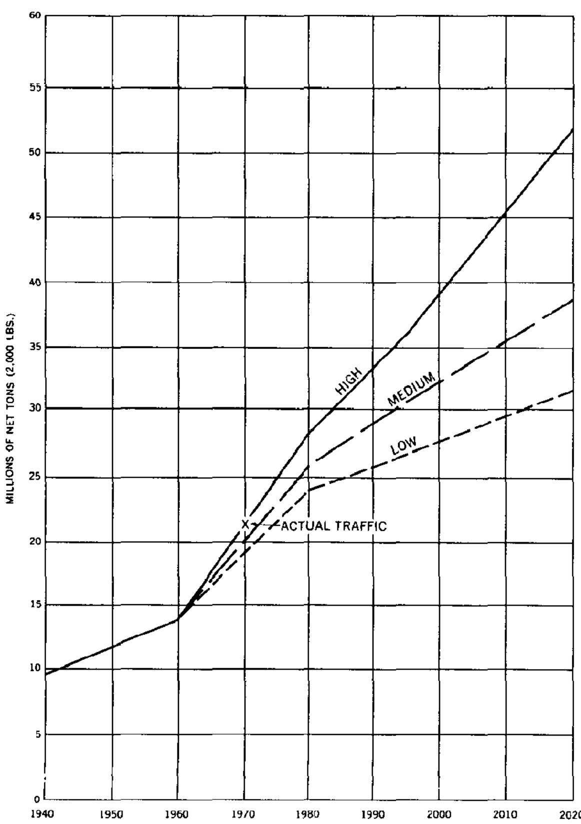


FIGURE C9–20 Grain Traffic on the Great Lakes-St. Lawrence Seaway

TABLE C9–66 Round Trip Hours of Projected Grain Shipments in Canadian Fleet in 1995

		Destination				
Type of Shipment	Origin Lake	Lake Michigan	Lake Huron	Lake Erie	Lake Ontario	St. Lawrence
Coastwise	Superior	---	220	260	290	328
Export	Superior	240	---	260	---	---
Import	Superior	---	---	---	320	324
Import	Michigan	---	220	---	380	285
Import	Erie	---	---	120	200	215

TABLE C9–67 Round Trip Time Factor of Loaded-Trip Time for Grain in 1995

Vessel Class	Overall Length (feet)	Grain Shipments
5	600-649	180% + 16 hrs
6	650-699	200% + 16 hrs
7	700-730	200% + 16 hrs

U.S. grain import levels. Domestic grain supply and export price fluctuation are closely aligned with the unpredictable forces of nature and the action of national governments on foreign trade policy. There has been a continued attempt to protect the countries' respective farm industries with legislation designed to minimize the price differential that may exist on agricultural produce. Thus, the Canadian grain trade and the American grain trade are largely competitive rather than complementary. A major factor in the fluctuation of grain imports is the system of import quotas enforced by the United States.

The imports of grain from Canada currently comprise less than 3 percent of the total grain traffic at U.S. Great Lakes ports. It was concluded that U.S. Great Lakes grain imports from Great Lakes Canada will continue to fluctuate because of weather, U.S. domestic supply and demand, and changes in governmental decisions affecting the price relationships of U.S. and Canadian grain, standards of classification of grain, and import quotas. In view of these intangible forces no long-range projections were estimated.

3.2.5.5 Canadian Coastwise Shipments

Canadian coastwise shipments of grain were estimated by the Statistics Canada at 14.3 million tons by 1995. Actual shipments in 1970 were approximately 10.7 million tons.

TABLE C9–68 U.S. and Great Lakes Grain Exports by Type of Grain, and Great Lakes Ports Percentage of U.S. Total, Average for 1959 to 1963, and Projections for 1980 to 2000 (Thousands of Tons)

Commodity	1959–63 Average[a]	1980	2000	2020
United States Total	34,741	52,200	62,000	73,000
Wheat	15,926	24,000	29,000	34,100
Corn	8,777	14,000	16,200	18,500
Oats	419	400	400	400
Barley-rye	2,242	2,820	3,000	3,500
Grain sorghums	2,804	3,640	4,400	5,000
Soybeans	4,431	7,200	9,000	11,000
Flaxseed	142	125	126	126
Great Lakes Total	4,900	11,000	13,800	16,700
Wheat	878	2,250	3,000	3,800
Corn	2,007	5,125	6,400	7,600
Oats	307	300	300	300
Barley-rye	681	1,150	1,300	1,500
Grain sorghums	2	-	-	-
Soybeans	913	2,075	2,700	3,400
Flaxseed	112	100	100	100
Ratio: Great Lakes to United States (Percent)				
Total-All Grains	14.1	21	22	23
Wheat	5.5	9	10	11
Corn	22.9	37	40	41
Oats	73.3	75	75	75
Barley-rye	30.4	41	43	43
Grain sorghums	0.1	-	-	-
Soybeans	20.6	29	30	31
Flaxseed	78.9	79	79	79

[a]Source: Reference 17.

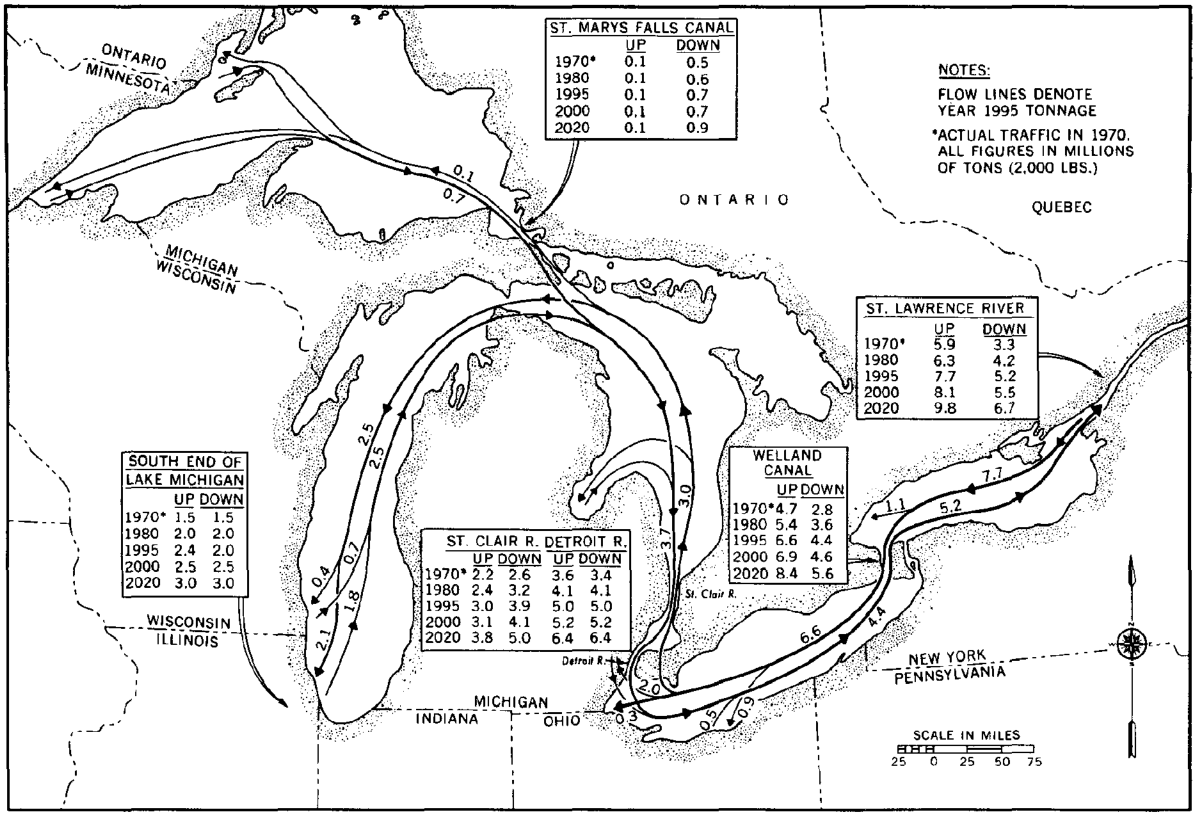


FIGURE C9–21 Projected Oversees General Cargo Traffic Flow, 1995

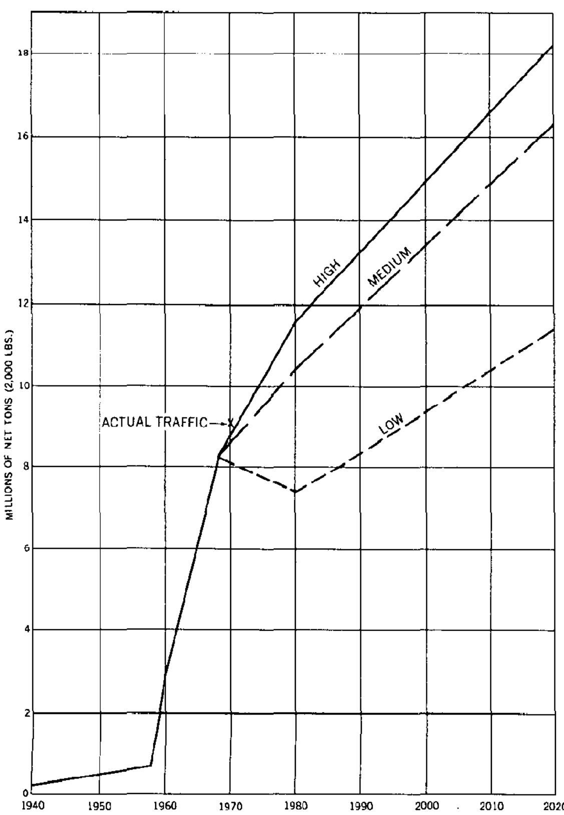


FIGURE C9–22 Overseas General Cargo Traffic on the Great Lakes-St. Lawrence Seaway

This rate of growth indicates coastwise shipments of 15.2 million tons in 2000 and 18.5 million tons in 2020. This is the medium projection.

3.2.5.6 Total Great Lakes Shipments

Projected grain shipments and the distribution pattern are shown in Tables C9–62, C9–63, C9–64, and C9–68. Mileages of projected shipments for the U.S. fleet, round-trip hours for the Canadian fleet, and round-trip time factors are shown in Tables C9–65, C9–66, and C9–67. Figure C9–20 shows the low, medium, and high estimates of prospective traffic. Figure C9–19 shows the grain flow pattern based on 1995 quantities and distribution.

3.2.6 Overseas General Cargo

The overseas general cargo traffic for all U.S. Great Lakes ports averaged approximately 500,000 tons annually during the 1952 to 1958 period prior to the completion of the St. Lawrence Seaway.[44] In the first year of the Seaway's operation (1959) this traffic in-

TABLE C9–69 Overseas General Cargo on the Great Lakes (Millions of Tons)

	1980	1995	2000	2020
Sixteen U. S. Interim Report Harbors	5.2	6.2	6.4	7.6
Other U. S. Harbors	2.6	4.6	4.9	6.2
Total U. S.	8.8	10.8	11.3	13.8
Canadian	1.7	2.1	2.2	2.7
Total	10.5	12.9	13.5	16.5

TABLE C9–70 Distribution of Other General Cargo

	Traffic (millions of tons)				
Harbor	1967	1968	Average	Percent Total	1995 Traffic
Duluth-Superior	0.381	0.349	0.365	13	0.6
Detroit	1.745	2.508	2.126	75	3.5
Toledo	0.350	0.332	0.341	12	0.5
Total	2.476	3.189	2.832	100	4.6

creased to 1,800,000 tons and has continued to increase each year, reaching 3,800,000 tons in 1964 and 8,000,000 tons in 1970. Table C9–71 shows the United States Great Lakes overseas freight traffic included and excluded from the general cargo traffic analysis from 1965 to 1969. U.S. overseas general cargo traffic is projected to increase to 8,800,000 tons by 1980; 11,300,000 tons by 2000; and 13,800,000 tons by 2020 (Tables C9–69 and C9–72). The total general cargo traffic at the 16 harbors that were subjects of interim reports in the Great Lakes Harbors Study averaged 364,000 tons annually for the 1952 to 1958 period prior to the Seaway's completion and 2,242,000 tons annually from 1959 to 1964, after the Seaway was completed. This traffic is to or from the Chicago-Milwaukee area. Ninety-five percent of traffic to harbors other than the 16 comprises traffic at Duluth-Superior, Detroit, and Toledo. All general cargo traffic attributed to other harbors is distributed to these three harbors as shown in Table C9–70 to allow development of a flow chart. Table C9–73 shows the overseas general cargo flow through connecting channels of the Seaway. Figure C9–22 shows the high, medium, and low estimates of prospective overseas general cargo and Figure C9–21 shows the overseas general cargo flow pattern for 1995.

TABLE C9–71 U.S. Great Lakes Overseas Freight Traffic Included and Excluded from the General Cargo Traffic Analysis, 1965 to 1969[44] (Short Tons)

	1965	1966	1967	1968	1969
Imports					
Included in General Cargo Analysis	3,738,471	3,953,984	4,290,967	6,358,021	4,688,859
Excluded from General Cargo Analysis	162,560	134,567	159,545	92,530	185,987
Total	3,901,031	4,088,551	4,450,512	6,450,551	4,874,846
Exports					
Included in General Cargo Analysis	2,074,384	2,061,247	2,411,493	2,244,036	4,008,992
Excluded from General Cargo Analysis	4,003,825	4,817,503	3,255,835	3,745,790	2,830,302
Total	6,078,209	6,878,750	5,667,328	5,989,826	6,839,294
Combined Total	9,979,240	10,967,301	10,117,840	12,440,377	11,714,140

TABLE C9–72 Projected Overseas General Cargo on the Great Lakes (Millions of Tons)

	1968[a]	1980	1995	2000	2020
High Projection:[b]					
United States	6.9	9.8	12.0	12.6	15.4
Canada[e f]	1.3	1.9	2.3	2.4	2.9
Total	8.2	11.7	14.3	15.0	18.3
Medium Projection:[c]					
United States	6.9	8.8	10.8	11.3	13.8
Canada[e f]	1.3	1.7	2.1	2.2	2.7
Total	8.2	10.5	12.9	13.5	16.5
Low Projection:[d]					
United States	6.9	6.2	7.6	8.0	9.6
Canada[e f]	1.3	1.2	1.5	1.5	1.9
Total	8.2	7.4	9.1	9.5	11.5

[a]On the basis of historical trends the 1969 overseas freight imports included in the General Cargo Analysis and the 1968 overseas freight exports are viewed as being representative of long term traffic trends.

[b]The growth between 1968 and 1980 is estimated at 3% a year. The annual rates of change beyond 1980 are the same as in footnote c.

[c]The growth between 1968 and 1980 is estimated at 2% a year. The annual rates of change from 1980 to 2020 (1.4% for 1980 to 1995; 1% from 1995 to 2020) are from U. S. Army Engineer Division North Central Great Lakes - Overseas General Cargo Traffic Analysis, March 1967, p. 126.

[d]The data taken directly from U. S. Army Engineer Division North Central Great Lakes - Overseas General Cargo Traffic Analysis, March 1967, p.126.

[e]The Canadian data represents traffic year 1966 and are for commodity groups which are included in the above cited Great Lakes - Overseas General Cargo Traffic Analysis. Source of this foreign waterborne commerce at Canadian Great Lakes Ports via the St. Lawrence River is Dominion Bureau of Statistics, Shipping Report 1966, Part II, International Seaborne Shipping, Table 4 (less U. S. traffic).

[f]The Canadian overseas general cargo traffic has been projected by using the same annual rates of change as the respective U. S. high, medium and low projections.

Overseas general cargo includes all but the following commodities:

(1) exports: grains, coal, coke, limestone, sand, gravel, sulphur, mineral ores, and concentrates

(2) imports: grains, sugar, bananas, pulpwood, coal, coke, petroleum products, limestone, sand, gravel, mineral ores, and concentrates

A major portion of existing tonnage at Chicago and Detroit (between 1 and 1½ million tons each annually) comprises imports of iron and steel products that may or may not continue in the future. Nevertheless, existing tonnages indicate that estimates of 1995 general cargo traffic may be conservative. The recently completed origin-destination study[50] is the first step in developing new estimates of general cargo traffic.

3.3 Summary

Past estimates of St. Lawrence Seaway traffic are summarized in Table C9–74.[18] Estimates of future traffic on the Great Lakes-St. Lawrence Seaway are summarized in Table C9–75. Estimated traffic through the connecting channels, the Welland Canal, and the St. Lawrence Seaway, for 1995 (medium estimate) is shown in Table C9–76 by individual commodity, and extrapolated to planning periods (assuming flow pattern does not change) in Table C9–77. Figure C9–24 shows the low, medium, and high estimates of prospective traffic on the Great Lakes-St. Lawrence system. The total traffic flow pattern for 1995 is given in Figure C9–23.

The estimates of iron ore and limestone traffic are considered more reliable than the estimates of coal, grain, and overseas general cargo because of uncertainties surrounding the latter. Nuclear power, liquefaction, gasification of coal, and emission standards affecting use of high sulphur coal will affect coal use in the future just as competing Canadian and U.S. domestic and foreign policies will affect grain. General cargo will be influenced by the impact of Canadian National rail movement from Chicago-Detroit to Montreal-Halifax.

The recent initiation of rail shipments of low sulphur coal from eastern Montana to the west end of Lake Superior, from where they are shipped by lake, and the possibility of shipments of lignite from North Dakota have not been analyzed in this study.[45] The possibility of lignite shipments is a result of the passage of the 1970 Clean Air Act. The sulphur content of western coal is generally low. The sulphur content in midwestern coal is high and Appalachian coal has a low-to-medium content. If pre-combustion emission standards specified by the Act are enforced, most midwestern coal would not be usable, according to available technology. Western coal (Colorado, Wyoming, and Montana) could be used to satisfy needs in Minnesota, Wisconsin, and Michigan, while most Appalachian coal would be shipped to other regions. Steam electric power plants in Michigan, Wisconsin, and Minnesota consumed 35 million tons of coal in

TABLE C9–73 Overseas General Cargo Flow Through Channels

Channel	Percent of 1969 Seaway Traffic		Traffic (millions of tons) 1980	1995	2000	2020
St. Marys River	6	Low	0.5	0.5	0.6	0.7
		Medium	0.6	0.8	0.8	1.0
		High	0.7	0.9	0.9	1.1
St. Clair River	53.4	Low	4.0	4.9	5.1	6.1
		Medium	5.6	6.9	7.2	8.8
		High	6.2	7.6	8.0	9.8
Detroit River	77.3	Low	5.7	7.0	7.3	8.9
		Medium	8.1	10.0	10.4	12.8
		High	9.0	11.0	11.6	14.1
Welland Canal	85.0	Low	6.3	7.7	8.1	9.8
		Medium	8.9	11.0	11.5	14.0
		High	10.0	12.1	12.8	15.5
St. Lawrence Seaway	100.0	Low	7.4	9.1	9.5	11.5
		Medium	10.5	12.9	13.5	16.5
		High	11.7	14.3	15.0	18.3

1970. A major portion of this could be supplied by western coal. Although coal is expected to hold a competitive edge over residual fuel oil in the upper Great Lakes region, the further east the coal travels the closer it is to a break-even point with the residual fuel oil. The location of the break-even point is very critical in determining future shipments of western low sulphur coal. Currently there is a moderate trend toward use of western coal. This trend will increase as the price of oil goes up. Improved technology for processing medium and high sulphur coal could reverse this trend at any time.

TABLE C9–74 Past Estimates of the St. Lawrence Seaway Traffic[a] (Thousands of Short Tons)

Authority	Year of Study	Minimum	Average	Maximum
A. H. Ritter	1925	--	30,174	--
Gregg & Cricher	1927	20,832	--	26,544
Moulton, Morgan & Lee	1929	--	10,563	--
Interdepartmental Group	1934	13,483	--	24,865
Danielian	1941	4,632	--	10,000
U. S. Department of Commerce	1948	57,787	--	82,287
Canadian Department of Trade and Commerce	1951	--	44,505	--
U. S. Seaway Corporation	1954	36,500(1959)	--	52,000(1965)
Canadian Seaway Authority	1956	--	30,000(1960-64)	--
U. S. Seaway Corporation	1957	34,200(1960)	--	54,500(1965)
Stanford Research Inst.	1964	43,500(1965)	59,100(1980)	76,700(2000)
Kates Associates	1965	43,600(1965)	74,600(1980)	143,900(2010)
Litton Systems, Inc. (U.S. Traffic only)	1968	8,960(1980)	--	64,592(2043)
E.B.S. Mgt. Cons. Inc.	1969	49,250(1966)	--	54,120(1980)

[a]The estimates are not precisely comparable. Some deal with potential for the year of the study, and some for the future. Many failed to specify the time limits.

Sources: A. H. Ritter, Transportation Economics of the Great Lakes-St. Lawrence Ship Channel, St. Lawrence Tidewater Association, 1925; Harold G. Moulton, Charles S. Morgan, Adah L. Lee, The St. Lawrence Navigation and Power Project, the Brookings Institution, Washington, D. C., 1929; E. S. Gregg and A. Lane Cricher, Great Lakes to Ocean Waterways, etc., U. S. Department of Commerce, 1927; Interdepartmental Board (War, Commerce and Federal Power Commission), Survey of the Great Lakes-St. Lawrence Seaway and Power Project; Danielian, the St. Lawrence Survey, Part III, U. S. Department of Commerce, 1941; Paul M. Zeis, Potential Traffic on the St. Lawrence Seaway, U. S. Department of Commerce, Transportation Division, 1948; The St. Lawrence Waterway and the Canadian Economy, Canadian Department of Trade and Commerce, Ottawa, 1951. Totals from U. S. St. Lawrence Seaway Development Corporation and Canadian Seaway Authority are the publicly announced figures drawn from unpublished reports. Economic Analyses of St. Lawrence Seaway, S.R.I., 1964. St. Lawrence Seaway Traffic Forecast, J. Kates Associates, 1965. Oceanborne Shipping, Litton Systems, Inc., 1968, includes only U. S. overseas cargoes. Seaway System Study, E.B.S., Inc., 1969.

TABLE C9–75 Waterborne Commerce Great Lakes-St. Lawrence System (Millions of Net Tons)

Projection and Commodity	Actual 1960	Actual 1970	Projected 1980	Projected 1995	Projected 2000	Projected 2020
Low						
Iron Ore	81.8	94.2	93.5	101.4	105.1	141.7
Coal	46.7	49.0	43.0	43.0	43.0	43.0
Limestone	27.2	36.1	35.9	40.8	42.6	51.1
Grain	14.1	21.7	24.4	26.6	27.4	31.8
Subtotal	169.8	201.0	196.8	211.8	218.1	266.6
Other (18% x Subtotal)	30.6	36.2	35.4	38.1	39.2	48.0
Overseas General Cargo	(3.1)	(8.2)	(7.4)	(9.1)	(9.5)	(11.5)
Total	200.4	237.2	232.2	249.9	257.3	314.6
Medium						
Iron Ore	--	--	123.8	153.7	164.0	221.0
Coal	--	--	62.0	74.0	74.0	74.0
Limestone	--	--	46.4	63.3	70.0	103.8
Grain	--	--	25.8	30.7	32.4	38.9
Subtotal			258.0	321.7	340.4	437.7
Other (18% x Subtotal)	--	--	46.4	57.9	61.2	79.0
Overseas General Cargo	--	--	(10.5)	(12.9)	(13.5)	(16.5)
Total			304.4	379.6	401.6	516.7
High						
Iron Ore	--	--	126.8	169.5	189.3	342.1
Coal	--	--	83.0	134.0	134.0	134.0
Limestone	--	--	57.0	91.3	106.8	201.4
Grain	--	--	28.5	36.6	39.3	52.1
Subtotal			295.3	431.4	469.4	729.6
Other (18% x Subtotal)	--	--	53.1	77.7	84.5	131.0
Overseas General Cargo	--	--	(11.7)	(14.3)	(15.0)	(18.3)
Total			348.4	509.1	553.9	860.6

TABLE C9-76 Estimate of 1995 Traffic Flow Through Channels (Millions of Net Tons)

Channel	Downbound	Upbound	Total
St. Marys Falls Canal			
Iron Ore	113.9[a]	---	113.9
Coal	---	7.8	7.8
Grain	22.0	---	22.0
Limestone	---	3.8	3.8
Subtotal	135.9	11.6	147.5
Other traffic (% x subtotal)	3.5 (2.6%)[b]	5.0[c]	8.5 (5.8%)[b]
Overseas general[d]	(0.7)	(0.1)	(0.8)
Total 1995 Traffic	139.4	16.6	156.0
St. Clair River			
Iron Ore	79.5	5.3	84.9
Coal	---	30.6	30.6
Grain	26.6	---	26.6
Limestone	17.4	0.9	18.3
Subtotal	123.6	36.8	160.4
Other traffic (% x subtotal)[e]	10.5 (8.5%)	7.8 (21.1%)	18.3 (11.5%)
Overseas general	(3.9)	(3.0)	(6.9)
Total 1995 Traffic	134.1	44.6	178.7
Detroit River[f]			
Iron Ore	80.0	5.0	85.0
Coal	---	50.0	50.0
Grain	26.6	---	26.6
Limestone	17.4	1.0	18.4
Subtotal	124.0	56.0	180.0
Other traffic (% x subtotal)[e]	12.3 (9.9%)	10.9 (19.5%)	23.4 (13.0%)
Overseas general	(5.0)	(5.0)	(10.0)
Total 1995 Traffic	136.3	66.9	203.4
Welland Canal			
Iron Ore	6.8	22.7	29.5
Coal	11.0	---	11.0
Grain	26.6	---	26.6
Limestone	---	---	---
Overseas general	4.4	6.6	11.0
Subtotal	48.8	29.3	78.1
Other traffic (% x subtotal)[g]	1.7 (3.5%)	2.5 (8.5%)	4.2 (5.3%)
Total 1995 Traffic	50.5	31.8	82.3
St. Lawrence Seaway (Montreal-Lake Ontario)			
Iron Ore	4.0	27.0	31.0
Coal	0.3	---	0.3
Grain	26.2	0.7	26.9
Limestone	---	---	---
Overseas general	5.2	7.7	12.9
Subtotal	35.7	35.4	71.1
Other traffic (% x subtotal)[g]	1.4 (3.8%)	5.2 (14.7%)	6.6 (9.3%)
Total 1995 Traffic	37.1	40.6	77.7

[a] A small amount (1.6 million tons) will be unloaded at Sault Ste. Marie (Algoma Steel).

[b] Based on 1968 U.S. and Canadian traffic.

[c] Difference between total and downbound tonnage.

[d] Overseas general is included in "other traffic."

[e] Based on 1968 and 1969 U.S. traffic.

[f] Substantial tonnages are unloaded at the Port of Detroit (principally Detroit Harbor, Rouge River, and Trenton Channel). Estimate made by assuming all traffic through St. Clair also going through at least part of Detroit River and about 20 x 10^6 tons of coal are estimated to travel through Detroit River to Port of Detroit destinations (this is added to 30.6 x 10^6 tons already traveling through to reach St. Clair River).

[g] Based on U.S. and Canadian traffic 1965-1969 (5-year average).

TABLE C9-77 Projected Traffic Through Channels for 1980, 2000, and 2020 (Millions of Net Tons)

Year	Great Lakes Total	St. Marys Falls Canal	St. Clair River	Detroit River	Welland Canal	St. Lawrence Seaway
1995	379.6	156.0	178.7	203.4	82.3	77.7
	Ratio: Channel Traffic to Total Traffic					
	1.000	0.411	0.470	0.535	0.217	0.214
	Low Projection					
1970[a]	228	81.0	109	126	62.9	51.1
1980	238.3	98	112	128	52	51
2000	269.3	111	127	145	58	58
2020	334.5	137	157	179	72	72
	Medium Projection					
1980	298.4	123	141	160	65	64
2000	401.6	165	189	215	87	86
2020	516.7	212	243	277	112	110
	High Projection					
1980	348.4	143	164	187	75	72
2000	553.9	227	261	297	120	114
2020	860.6	354	405	460	187	184

[a]Actual 1970 traffic.

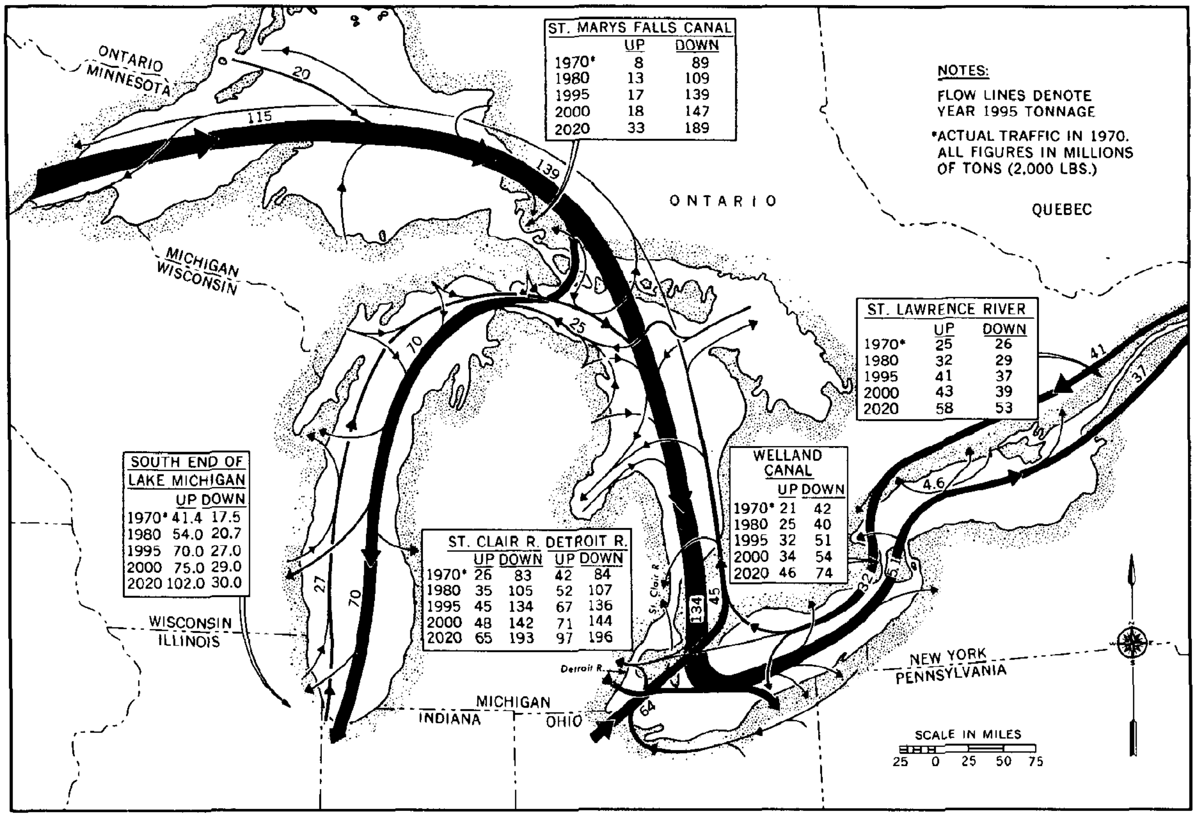


FIGURE C9–23 Projected Total Traffic Flow, 1995

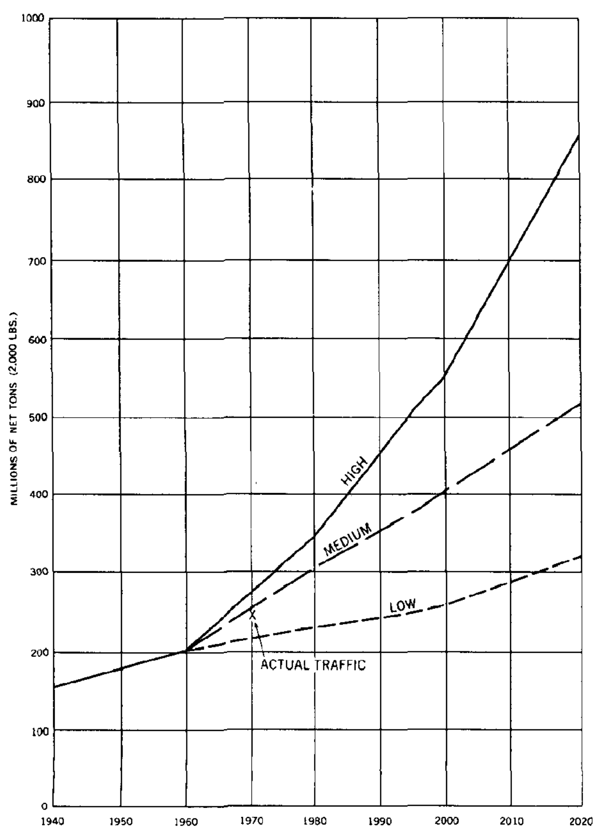


FIGURE C9–24 Total Traffic on the Great Lakes-St. Lawrence Seaway

Section 4

EXISTING AND FUTURE VESSEL FLEET AND OPPORTUNITIES FOR TECHNOLOGICAL ADVANCEMENT

4.1 Existing Great Lakes Fleet

4.1.1 General

The Great Lakes and St. Lawrence Seaway fleet comprises two types of ships, domestic lakers and ocean-going vessels (Table C9–78). The domestic fleet operates exclusively within the Great Lakes and St. Lawrence Seaway extending from the Gulf of St. Lawrence to the head of Lake Superior. Ocean-going vessels carry cargoes to or from lake and overseas ports outside the Seaway system.

The world fleet has changed remarkably in the past 10 years. World ports now deal with special purpose ships carrying chemicals, molten sulphur, liquified natural gas, wine, and orange juice. Dry bulk carriers of 165,000 tons and tankers up to 500,000 tons have appeared.

The shipping revolution in the Great Lakes has been equally evident. The years since World War II have marked the collapse of the historic Great Lakes package fleet trade, the

TABLE C9–78 Great Lakes and St. Lawrence Seaway Waterborne Fleet, 1970

	Domestic Laker Fleet										Ocean-Going Fleet			
	Dry Bulk Carriers		Self Unloaders		Tankers		Crane Vessels		Package Freighter		Bulk Carriers		General Cargo	
	No. of Vessels	% of Total	No. of Vessels	% of Total	No. of Vessels	% of Total	No. of Vessels	% of Total	No. of Vessels	% of Total	No. of Vessels	% of Total	No. of Vessels	% of Total
Construction Period														
1890 - 1909	53	19.9	21	28.7	1	1.6	7	77.8	1	2.3	--	--	5	1.5
1910 - 1929	69	25.9	25	34.2	12	19.4	1	11.1	3	6.8	--	--	7	2.7
1930 - 1949	51	19.2	9	12.4	25	40.4	--	--	9	20.4	--	--	19	7.3
1950 - 1959	50	18.8	7	9.6	8	12.8	--	--	17	39.1	5	20	109	40.2
1960 - 1965[a]	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1965 - Present	43	16.2	11	15.1	16	25.8	1	11.1	14	31.8	20	80	131	48.3
Vessel Length (ft.)														
0 - 199	13	4.9	3	4.1	7	11.3	1	11.1	31	70.4	--	--	28	10.3
200 - 299	14	5.3	5	6.8	19	30.6	2	22.2	4	9.2	--	--	7	2.7
300 - 399	18	6.8	3	4.1	25	40.3	3	33.4	2	4.5	--	--	41	15.1
400 - 499	11	4.1	6	8.2	10	16.2	2	22.1	7	15.9	4	16	134	49.4
500 - 599	40	15.0	28	38.3	1	1.6	1	11.1	--	--	11	44	61	22.5
600 - 699	122	45.9	20	27.5	--	--	--	--	--	--	7	28	--	--
700 - 730	48	18.0	8	11.0	--	--	--	--	--	--	3	12	--	--
Over 730[a]	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dead Weight at 25'6" (Long tons)														
0 - 4,999	32	12.0	11	15.1	42	67.7	4	44.4	38	86.3	--	--	43	15.9
5,000 - 9,999	26	9.8	17	23.3	17	27.4	4	44.4	6	13.7	1	4	180	66.3
10,000 - 14,999	103	38.7	26	35.6	3	4.9	1	11.2	--	--	9	36	42	15.5
15,000 - 19,999	42	15.8	7	9.6	--	--	--	--	--	--	7	28	6	2.3
Over 20,000	63	23.7	12	16.4	--	--	--	--	--	--	8	32	--	--
Total Number of Vessels	266	100	73	100	62	100	9	100	44	100	25	100	271	100
Percent of Total	35.5	--	9.7	--	8.2	--	1.2	--	5.8	--	3.3	--	36.1	--

[a]No vessels were built in this category.

NOTE: The domestic fleet has decreased from about 710 ships in 1950 to the 454 ships shown above and will probably fall to less than 300 by 1995 or 2000. See Table C9-80.

demise of Great Lakes passenger ships, and the retirement through bloc obsolescence of several hundred small "canallers," which were uneconomical and incapable of survival in an era of mass production and mass movement. The Great Lakes fleet is now characterized by fewer but larger vessels, deeper draft requirements in harbors and channels, and even more emphasis on automated handling. The Great Lakes Region pioneered in vessel automation with the first self-unloading ships and the first giant dockside equipment for continuous automated handling of grain, coal, cement, and iron ore. Figures C9-25 through C9-31 show various types of vessels that travel the Great Lakes.

4.1.2 Domestic Laker Fleet

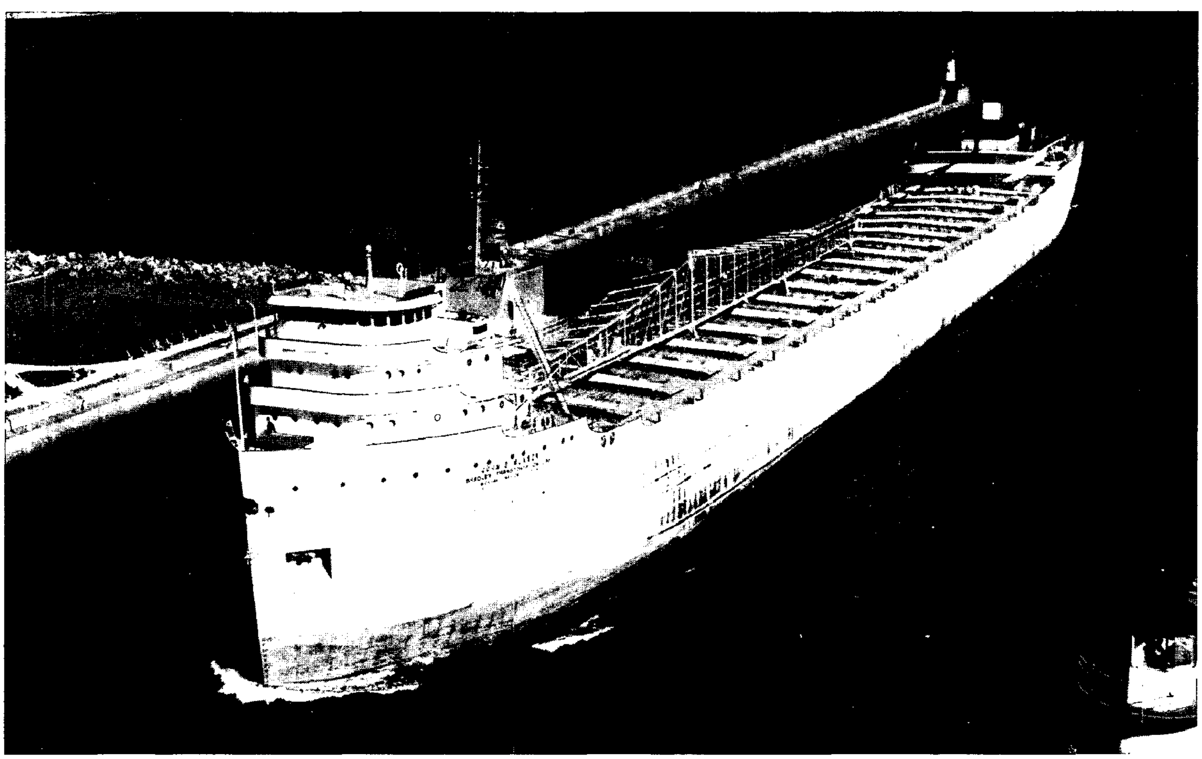
As of December 31, 1969, this fleet, which operates exclusively within the Lakes, consisted of five vessel types totalling 454 vessels. There were 266 dry bulk carriers, 73 self-unloaders, 62 tankers, 9 crane vessels, and 44 general cargo carriers.[14]

4.1.2.1 Dry Bulk Carriers

Dry bulk carriers are the most significant in terms of both tonnage and number. These vessels are primarily involved in the iron ore and grain trades. Some also carry coal and stone.

Of the 266 vessels (Table C9-78) actively engaged in domestic dry bulk transportation in 1970, 63.9 percent were 600 feet or more in length. In terms of cargo capacity, 78.2 percent of the dry bulk fleet carries 10,000 long tons or better. Sixty-five percent of the fleet is 20 or more years old. Nearly half of the fleet (45.8 percent) is 40 or more years old. The U.S. flag portion, with an average vessel age in excess of 45 years, is older than the Canadian. Thirty-six of the 48 vessels in the 700 to 730 foot long category (designed to fit the dimension of the St. Lawrence Seaway and Welland Canal locks) are Canadian. All but one, which was built in 1954, were constructed between 1959 and 1969.

Vessel age directly affects the cost of bulk transportation service. Many vessels in the dry bulk carrier fleet are fully amortized, which allows their owners to operate them



Courtesy of Lake Carriers' Association

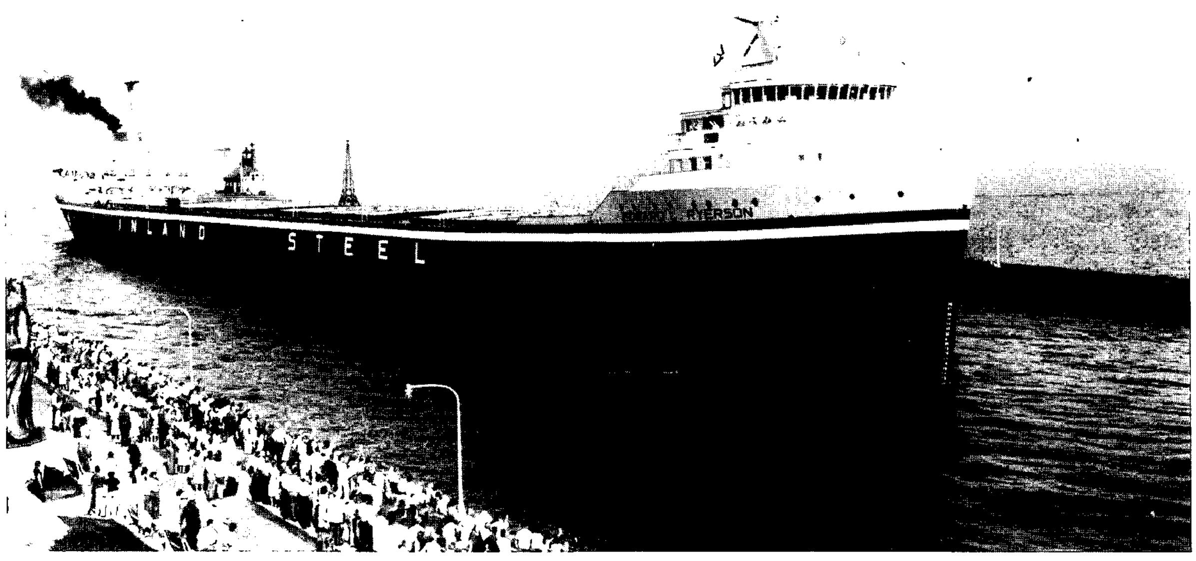
FIGURE C9-25 The *John G. Munson* Self-Unloader. This U.S. Steel Corporation vessel, a 666-foot self-unloader built in 1952, is shown entering Duluth-Superior Harbor.

profitably at an extremely low rate. It has been estimated that a 17,000 ton, 600-foot dry bulk carrier that is fully depreciated can cover its annual operating costs with a freight rate of slightly less than $1.00 per long ton.[53] Vessel operators with newer equipment, which has not fully depreciated, are subject to intense rate competition that prohibits an adequate return on the capital invested in their vessels. The 1970 Merchant Marine Act, however, permits lake vessel operators to deposit earnings in tax-deferred construction reserve accounts for use in building new ships. This relieves some of the rate competition and also supplies some needed incentives to construct newer and more efficient lake vessels.[22]

4.1.2.2 Self-Unloaders

These vessels are essentially adaptations of the basic dry bulk vessel. The difference is that the self-unloader is fitted with its own unloading system, usually conveyor belts. This self-unloading ability makes the vessel efficient and flexible in its use. It is attractive to the ship operator because it has a rapid port turn-around time and is not restricted to serving docks that have unloading equipment. It is attractive to the dock operator because it requires a minimum of dock equipment, only an open area within reach of the vessel's unloading boom and large enough to hold the amount being unloaded. The fleet numbers 73, 65.8 percent of which is between 500 and 699 feet in length. Vessels with less than 15,000 long-tons capacity comprise 74 percent of the fleet. In terms of carrying capacity and length, the average self-unloader, which carries mainly coal and limestone, is smaller than the average dry bulk vessel so that it can call at shallow draft harbors and at industrial plants with limited dock storage. Nine new vessels have been added to the Canadian fleet since 1965. The remainder of the fleet are vessels that have been converted to the self-unloading type.

The increased pelletization of iron ore is opening a new segment of commerce to self-unloaders. Many natural iron ores have physical characteristics that prevent them from being handled readily by belt conveyor systems. Since most self-unloaders use belt con-



Courtesy of Lake Carriers' Association

FIGURE C9–26 The *Edward J. Ryerson* Bulk Carrier. This 730-foot carrier, shown entering Duluth-Superior Harbor, was built for Inland Steel Company in 1960.

veyor systems, they have been excluded from the ore movement. Pellets, however, can be handled by belt conveyors. Some pellets now are transported by self-unloaders, and it is expected that in the future, these vessels will play a major role in transportation of iron ore pellets.

In 1972 two new U.S. ore self-unloaders for the U.S. Steel and Bethlehem Steel Corporations were placed in service. These vessels are unique in size and capacity. U.S. Steel's vessel (the *Roger Blough*) is 858 feet long and 105 feet in beam, while Bethlehem's (the *Stewart Cort*) is 1,000 feet long and 105 feet in beam. (See references 40 and 58.) This increase in vessel size was permitted by the completion of the Poe Lock at Sault Ste. Marie. The principal characteristics of these vessels are shown in tabular form below.[14]

The *Cort* is constructed so that its draft can be increased to 30 feet 6 inches by the addition of a minimum amount of steel strapping to the upper deck. At a draft of 30 feet 6 inches the vessel can carry approximately 73,000 net tons of iron ore. The average operating speed is 16.5 miles per hour. The vessel was designed to de-ballast in less than three hours. It can be loaded and unloaded at 10,000 net tons per hour. The *Cort* carried 2,100,000 net tons from Taconite Harbor to Burns Harbor in 35 trips between 4 May and 23 December, 1972. The largest cargo was 62,500 net tons. The average cargo per trip was 60,000 net tons.

The *Roger Blough* carried more than 1,100,000 net tons in its first season on the Lakes, although it operated only slightly over four months. The *Blough* is designed to unload at a rate of approximately 11,000 net tons per hour.

A third vessel, the *Presque Isle*, a 1,000-foot-long tug-barge, so called because the power unit is detachable from the remainder of the vessel, commenced its maiden voyage from Two Harbors, Minnesota on December 21, 1973, carrying 57,000 net tons of taconite pellets bound for the U.S. Steel works in Gary, Indiana. The *Presque Isle* unloads at the rate of 10,000 net tons per hour.

A contract was signed in the fall of 1973 for the building of two additional 1,000 foot ships at a total cost of $70 million. A key factor in the decision to build the ships, scheduled for completion in 1976 and 1977, was the building of a new 5.4 million ton iron ore pellet plant in Minnesota for Bethlehem Steel Corporation. Each of the vessels will carry 66,000 net tons of iron ore or 58,000 net tons of coal. Unloading speed will be 10,000 net tons per hour. A drydock option is held for two additional 1,000-footers that could follow.

4.1.2.3 Tankers

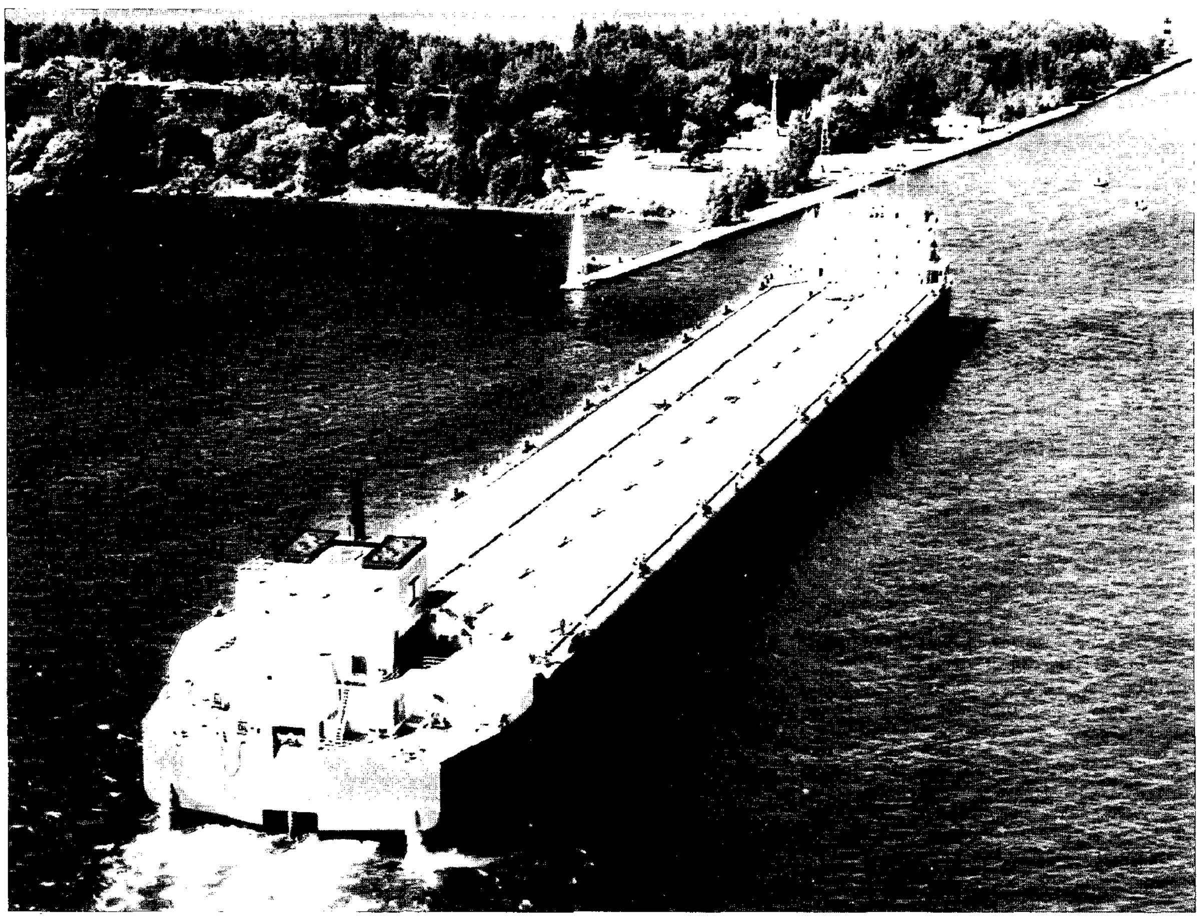
This fleet of 62 vessels transports refined petroleum products between refining centers and consuming centers located on the Great Lakes. Approximately 70.9 percent of the Seaway tanker fleet is between 200 feet and 399 feet in length with 67.1 percent of the fleet having less than 5,000 ton capacity. Size of these domestic tankers, obviously smaller than the self-unloader and dry bulk types, is limited by the smaller shallow draft harbors in which they trade. Competing oil pipelines serve the major port areas.

4.1.2.4 Crane Vessels

These ships deal mainly in the steel-scrap and sulphur trades. The crane vessels average around 300 feet in length with 88.8 percent having a carrying capacity less than 10,000 long tons. Only one vessel of this small fleet was built originally for that purpose. The

Characteristics of the *Roger Blough* and the *Stewart Cort*

	Current Seaway Vessel Size	U.S. Steel 858 ft. Self-Unloader Vessel *Roger Blough*	Bethlehem Steel 1,000 ft. Self-Unloader Vessel *Stewart Cort*
Length	730 ft.	858 ft.	1,000 ft.
Beam	75 ft.	105 ft.	105 ft.
Design Draft	27 ft. 3 in.	28 ft.	27 ft. 10 in.
Capacity at Design Draft	31,200 ST (2,000 lbs)	50,600 ST	65,000 ST
Capacity at 25′9″ Draft	28,000 ST	45,500 ST	56,000 ST
Lost Capacity	3,200 ST	5,100 ST	9,000 ST



Courtesy of North American Films

FIGURE C9–27 The *Stewart J. Cort* Self-Unloader. A 1,000-foot vessel built for Bethlehem Steel in 1971, the *Stewart J. Cort* is shown leaving Erie, Pennsylvania. The vessel contains a belt conveyor unloading system designed for the pellet trade.

eight other vessels are reconstructed ships of 55 years of age or older.

4.1.2.5 Package Freighters

Of the 44 vessels in the domestic general cargo package fleet, 54.4 percent are less than 100 feet long, and 81.8 percent have a carrying capacity of less than 2,000 long tons. Most of this fleet operates on a regular schedule. The majority are Canadian-owned. The United States fleet is virtually non-existent because of competition from the highly developed U.S. highway system.

This fleet is relatively new, and 61.8 percent of the package freighters were built within the past 15 years. Some of the newer vessels are equipped with side ports for rapid handling of pelletized freight. With the aid of fork-lifts, these vessels have an extremely high unloading rate. Their rapid loading and unloading capability and young age make this fleet the most up-to-date element of the Seaway system.

4.1.3 The Ocean-Going Fleet

Ocean-going vessels have limited access to the Great Lakes-Seaway waterway due to the dimensions of its locks and channel depths. The Seaway draft limitation of 25 feet 6 inches often forces vessels to carry less than their maximum design capacity. As of December 31, 1969, the ocean-going Seaway fleet numbered 296 American, Canadian, and foreign vessels. The fleet has been broken down into two types, the newer bulk carriers and conventional break-bulk general cargo ships.

4.1.3.1 Bulk Carriers

The ocean-going bulk carrier fleet is composed of 25 vessels, which average approximately 600 feet in length. The current trend is toward construction of larger ships upwards to the 730-foot Seaway maximum. These vessels are comparatively new. All were constructed within the past 15 years, and are used to carry dry bulk cargoes (such as grain), general cargo (such as steel products), and even some containers. At a draft of 25 feet 6 inches, 60 percent of these ships have capacities of 16,000 tons or greater. Forty-four percent of the vessels have the maximum permissible beam of 75 feet. Only one vessel has a summer draft that is 25 feet 6 inches or less, leaving 96 percent of these carriers transporting less than their actual potential carrying capacity. The total lost capacity of these 24 vessels at a summer draft of 25 feet 6 inches is 156,445 deadweight tons. This means that the average Seaway ocean-going bulk carrier is losing 6,500 tons of potential capacity because of the Seaway draft restriction. Three new Norwegian sister ships, the *Rolwi*, *Nanfri*, and *Andwi*, are the largest of these bulk carriers in operation. They have lengths of 709 feet, beams of 75 feet, and design drafts and deadweights of 36 feet and 35,700 tons. At a draft of 25 feet 6 inches their capacity is limited to only 22,175 deadweight tons, thus losing a potential 13,525 tons of cargo each.

4.1.3.2 General Cargo

The conventional ocean-going general cargo fleet, numbering approximately 271 vessels, is much larger than the ocean-going bulk fleet. These vessels average between 400 and 500 feet in length with the greatest proportion (57.2 percent) built during the 1955 to 1965 era. A majority of these freighters have carrying capacities of less than 10,000 deadweight tons at a 25 feet 6 inch draft. These vessels are smaller in length and capacity and are slightly older than the ocean-going bulk carriers. Operators make maximum use of these vessels by carrying bottom loads of grain and edible oils with top loads of general cargo, containers, and heavy lifts. In addition, nine of these vessels have been converted into partial cellular containerships capable of carrying more than 150 standard 20-foot containers.

Approximately 58.4 percent of these ships have drafts in excess of 25 feet 6 inches. Together they sacrifice 314,415 deadweight tons of carrying capacity. The average lost capacity for these 158 ocean-going general cargo vessels is 2,040 deadweight tons per vessel.

4.2 Opportunities for Technological Advancement

The future Great Lakes-St. Lawrence Seaway fleet cannot be fully evaluated without knowledge of technological developments and innovation in other transport and in industry distribution and collection practices.

Great Lakes shipping has received considerable stimulation from the passage of the Merchant Marine Act of 1970 and from the newly constructed Poe Lock at Sault Sainte Marie, which will accommodate vessels up to 1,000 feet long and 105 feet wide. At the present time, however, innovative vessel design is not being pursued for the Great Lakes-Seaway system. Substantial investments in research, ships, shore facilities, and changes in trade practices are now required.[24]

The effect of transportation technology on the existing and projected commerce for domestic bulk carriers and the general cargo ocean-going fleet is critical for future Great Lakes-St. Lawrence River shipping.

4.3 Future Great Lakes Fleet

4.3.1 Domestic Dry Bulk

The existing U.S. domestic dry bulk fleet, despite its age, is still an active, economically viable transportation system on the Great Lakes-St. Lawrence system.[53] Incentives for modernizing the U.S. flag fleet were provided by the Merchant Marine Act of 1970, which created tax-deferred reserve accounts for acquisition, construction, and reconstruction of vessels. The prospective (1995) bulk fleet has been estimated for the Great Lakes Water Levels Study[20] based on medium projections for iron ore, coal, limestone, and grain, (Table C9–75), distribution of commerce to the various classes of vessels (estimated for the Great Lakes Levels Study and shown in Table C9–79), and vessel characteristics such as capacity, draft, speed, and size (Table C9–80).

Data in Tables C9-79, C9-80, and C9-81 were used to determine the number of vessels in each class of the 1995 fleet that would be required to carry the 1995 medium commerce projections. The fleet capacity would be 8.5 million deadweight tons. Using these same assumptions, the percent of the fleet that would be required to carry the high and low projections of traffic can be estimated by simple projection. The low projection yields iron ore, 78 percent; coal, 58 percent; limestone, 64 percent; and grain, 87 percent. The high projection yields iron ore, 110 percent; coal, 181 percent; limestone, 144 percent; and grain, 119 percent.

TABLE C9-79 Projected Distribution of Shipments by Vessel Class and Commodity Trade for 1995[a]

Vessel Length	Vessel Class	Percent of Annual Shipment Tonnage: Iron Ore	Bituminous Coal	Limestone	Grain
		United States Fleet			
550'- 599'	4	--	25	20	--
600'- 649'	5	20	25	20	33
650'- 699'	6	10	25	10	33
700'- 730'	7	10	25	10	34
731'- 849'	8	20	--	20	--
850'- 949'	9	20	--	20	--
950'-1,000'	10	20	--	--	--
		100	100	100	100
		Canadian Fleet			
1'- 399'	1	--	.9	--	3.1
400'- 499'	2	--	.7	3.3	--
500'- 599'	4	--	.6	4.5	1.7
600'- 649'	5	1.6	7.6	13.4	6.9
650'- 699'	6	2.0	3.1	5.4	8.3
700'- 730'	7	84.0	87.1	73.4	61.4
950'-1,000'	10	12.4	--	--	18.6
		100.0	100.0	100.0	100.0

[a]Due to the recently completed Canadian ship building program, the characteristics of the U. S. and Canadian 1995 fleets will differ since the U. S. 1995 fleet will embody more advanced design concepts.

Some generalizations about the future fleet can be inferred from trends that are well established at this time. Foremost among these is the preference for larger vessels as replacements for vessels leaving service. Replacements will have two or more times the carrying capacity of vessels replaced. Their propulsion power and resultant speed will be greater, their hulls approximately structured for winter operation, and their loading and unloading facilities will be improved. Replacement vessels will carry more tonnage faster, more days of the year, than present vessels do. These factors, viewed in the light of comparatively modest increases in total tons moved, indicate a numerically smaller fleet. The fleet may include large deadweight barge carriers, such as the 50,000 ton tug-barge system recently constructed at Litton's shipyard in Erie, Pennsylvania.

TABLE C9-80 Projected Vessel Data for 1995

Vessel Class	Maximum Cargo Capacity in Net Tons: Iron Ore	Bituminous Coal	Limestone	Grain	Vessel Draft at Max. Cargo Carrying Capacity	Ave. Vessel Speed Statute m.p.h.	Vessel Net Ton Capacity Per Foot of Immersion (For Drafts in Excess of 18 Feet)	Total 1972 Operating Cost/Hour
				United States Fleet				
4	16,100	13,300	16,100	16,100	22.5	14	920	$ 297
5	22,800	18,400	22,800	22,800	25.6	14	1170	328
6	24,000	19,500	24,000	24,000	26.3	14	1230	348
7	28,900	21,900	28,900	28,900	27.2	14	1390	366
8	45,000		45,000		29.5	17	2150	481
9	51,000		51,000		31.0	17	2300	513
10	62,000		62,000		32.0	17	2650	594
				Canadian Fleet				
1	6,407	6,407	6,407	6,407	23.5	17	423	179
2	10,520	10,520	10,520	10,520	21.1	17	774	208
4	17,873	16,900	17,873	16,900	23.8	17	1021	228
5	21,600	19,925	21,600	19,925	24.6	17	1037	228
6	25,984	22,900	25,984	22,900	26.4	18	1309	251
7	30,600	30,600	30,600	30,600	27.2	18	1560	252
10	62,000			62,000	32.0	18	2650	287

TABLE C9–81 Prospective Great Lakes Dry Bulk Cargo Fleet (Dry Bulk Carriers and Self-Unloaders), Medium Traffic Projection for 1995

Vessel Class	Iron Ore	Lime-stone	Coal	Grain	Total
	Commodity				
	United States Fleet				
1	--	--	--	--	--
2	--	--	--	--	--
3	--	--	--	--	--
4	--	--	8	--	8
5	27	6	8	2	43
6	14	3	8	2	27
7	12	3	7	2	24
8	12	3	--	--	15
9	11	3	--	--	14
10	9	--	--	--	9
Total	85	18	31	6	140
	Canadian Fleet				
1	--	--	1	10	11
2	--	1	1	--	2
3	--	--	--	--	--
4	--	1	1	2	4
5	2	1	2	7	12
6	2	1	1	7	11
7	42	4	11	38	95
8	--	--	--	--	--
9	--	--	--	--	--
10	3	--	--	6	9
Total	49	8	17	70	144
Combined Total	134	26	48	76	284

4.3.2 Domestic Tanker

The domestic tanker fleet is expected to remain constant in number and total tonnage. The present average tanker vessel is smaller than the physical constraints of the Seaway and it is expected that future tankers similarly will not exceed the Seaway's maximum permissible dimensions. Petroleum pipelines are expected to take on some of the routes now supplied by tankers as lines are extended to more consuming centers.

4.3.3 Domestic General Cargo

There is no U.S. flag fleet because of motor carrier and air freight transportation of high-value cargoes.

The Canadian share of this trade will continue to grow at a moderate rate. Pelletization will remain its prime cargo-handling procedure. Canadian package freighters will compete strongly for domestic container cargo moving within the Hamilton-Toronto-Montreal corridor. The Canadian National Railroad also handles containers for domestic delivery and transfer. Its integrated railway system, while complementing the ocean-going container shipping lines, will be the primary competitive force for any domestic container traffic moving on package carriers.

4.3.4 Overseas Fleet

It is anticipated that by 1980 perhaps as much as 80 percent of the present Seaway-overseas fleet will be in need of replacement. This offers an excellent opportunity to construct new vessels incorporating design features tailored to the existing characteristics of specific trade routes and existing limitations of the Seaway system.

The maritime industry is currently in the midst of unprecedented technological change in ocean shipping operations, which affects both equipment and cargo handling methods. Large, fast full-containerships are presently in operation transporting containerized general cargo on the North Atlantic and Pacific high-value, high-volume trade routes. Barge-carrying ocean vessels capable of receiving and dispatching pre-loaded cargo lighters at anchor for towing to and from multiple ocean and river ports will be entering service in greater number in the next few years. Combination ocean barge-tug service is also expected to grow rapidly. Ocean-going barges of up to 50,000 tons are being designed and constructed to carry dry, liquid, and refrigerated cargoes, propelled by pusher tugs rated at more than 10,000 horsepower. This new concept in deep sea transportation could potentially be used instead of conventional cargo ships.

Overseas general cargo volume through the Seaway system is expected to continue to grow during the next decade despite the competing container shipping services by U.S. and Canadian railways to East Coast ports. Part of this growth will occur in general cargo not suitable for containerized general cargo and where speed of delivery is less important than cost of transportation.

The theme of the design and size of future ships to serve Great Lakes-overseas general cargo traffic requirements in the next decade will be adaptability and flexibility. In addition to accommodating break-bulk and pelletized cargoes, many of these multi-purpose ships will also be capable of carrying partial cellular loads of standard containers, roll-on/roll-off cargoes, bulk grains, liquids, and other dry and refrigerated commodities. The partial cellular containerships recently put into Great Lakes service by several foreign flag liner operators for direct movement to Western European ports exemplify one type of multi-purpose vessel expected to serve the future general cargo traffic needs of the Great Lakes-Seaway region.

The trend toward such flexible ships will also be reflected in the direct overseas volume movements of dry bulk cargoes such as wheat, corn, and soybeans.[10] Several new, multi-purpose bulk carriers are already in service in the Lakes-overseas grain trades. These modern vessels can carry full loads (23,000 tons) of dry bulk commodities, including break-bulk general cargo such as steel products and a number of deck-loaded containers.

Efforts by the Maritime Administration to develop preliminary vessel designs to increase U.S. participation in foreign trade may also further the trend toward multi-purpose, ocean-going vessels serving the Great Lakes general cargo and dry bulk trades. Design competition has already resulted in the development of a multi-purpose carrier known as the *Kennebec Class* which transports break-bulk and pelletized cargoes, containers, grains, and ores. This highly versatile ship, with a 570-foot length, 75-foot beam, and a 21,000 ton deadweight tonnage ocean service carrying capacity, possesses the characteristics for successful Great Lakes-Seaway operations. An elongated version of this class could also be constructed and operated as a 20,000 deadweight tonnage Seaway service vessel or a 27,000 deadweight tonnage ocean service ship.

Concern has been expressed that the rapidly growing world fleet of containerships will seal the fate of the traditional break-bulk general cargo ships now operating on the Seaway system and that these break-bulk vessels may be displaced by the competing, intermodal rail-containership services provided at eastern Canadian and U.S. ports. However, there is and will continue to be a definitive need on the Great Lakes for conventional general cargo vessels to carry commodities that are neither physically or economically amenable to container transport. These vessels will also be in demand to provide Great Lakes services to many areas in Africa, South America, India, and the Far East where harbors, industries, and connecting rail and road systems are still relatively undeveloped.

Although containerized cargo moving through the Seaway system in the future is expected to be handled both conventionally on break-bulk general cargo ships and cellularly on multi-purpose partial containerships, heavier- and lower-rated general cargoes unamenable to containerization will predominate in the Lakes-overseas trades. Because these conventional general cargo vessels and multi-purpose carriers will have to maintain a relatively wide operational flexibility in and out of many developed and undeveloped world ports, their size is not expected to increase significantly.

Economies of more mechanized cargo handling gear, improved propulsion equipment for greater speed, modifications of hull forms and automated systems are expected to play a more important role in the future development and operation of Great Lakes general cargo and multi-purpose vessels than increases in size.

Various factors may limit the Great Lakes-Seaway system's potential development of full-containership services for its overseas general cargo trades:[53]

(1) vessel size and draft restrictions imposed by the present dimensions of Seaway locks and depths of its channels

(2) lack of a year-round shipping season

(3) lack of sufficient container cargo generating capacity

(4) lack of adequate, specialized container-handling lake port facilities

(5) inability to generate sufficient investment capital at lake ports

The new generation of large full-containerships are not suited to the present Lakes-overseas trades. They are too wide, fast, and expensive to be committed to the slow inland journey through the tolled Seaway and to a limited shipping season. Because much of the efficiency of the containership depends on rapid turnaround, these expensive vessels cannot afford to stop at the multiple port network characteristic of the Lakes-overseas general cargo trades and then top off their loads at lower St. Lawrence ports to achieve deeper drafts. Volume cargo aggregation at a few major lake ports is necessary for full-containerships to continue to service the Great Lakes.

With the possible exception of Chicago, most general cargo lake ports cannot generate enough container cargo to support a costly specialized terminal for full-containership operations. The Great Lakes-overseas general cargo traffic consists more of high-weight, high-density, low-value cargoes, such as iron and steel products, than the higher-value, packaged merchandise that is more suitable to containerization. Recent studies by Professor Eric Schenker of the University of Wisconsin have shown that 72 percent and 81 percent of the Lakes-overseas general cargo imports and exports respectively are physically and economically unsuited to container transport. By 1985 only approximately 25 percent of the Lakes general cargo traffic is expected to be suited for containerization (see references 35 and 37).

Other important factors inhibiting the container generating potential of the Great Lakes are that the Seaway handles less than 20 percent of the general cargo exports generated in its hinterland and few lake ports do more than 10 percent in export-import business. Reasons for this include alleged discriminatory rail rates and inequitable services, shippers' habits and inexperience with the Seaway, the short shipping season in the Great Lakes, and insufficient sailings to certain world areas.

Another reason operators of full-containerships are not inclined to service the Lakes is lack of adequate, specialized container port facilities designed to achieve rapid turn-around time. The lake ports at present have no berths to accommodate full-containerships and appear to have no immediate plans to build any such facilities. In addition few lake ports can generate sufficient capital to provide the necessary space, equipment, and facilities. The cost of a single container berth with marginal wharf, 10 to 20 acres of land, and two large container cranes requires capital investment of at least five million dollars.

Since every lake port cannot afford to build modern container facilities, some sort of coordinated regional planning appears to be one way the major general cargo lake ports can prevent losing container traffic to coastal ocean ports while retaining their financial stability. It has been suggested that the Great Lakes ports as a unit consider the development of two modern, fully-integrated container terminal facilities: one at the southern end of Lake Michigan serving Chicago and Milwaukee, and one on Lake Erie to service eastern lake ports such as Detroit, Toledo, and Cleveland (see references 35 and 37).

Since competitive and political pressures may make regional port planning virtually impossible, the remaining alternative is independent port planning for future container terminal needs. In this respect, it appears that in the near future only the Port of Chicago will have sufficient containerized general cargo traffic to support a full-container terminal berth. Toledo may be the only other lake port that has excellent potential for future container terminal development. It has available land, excellent rail and highway services, good hinterland penetration, and a rapidly rising volume of container traffic.

Provision of direct overseas full-containership Great Lakes services appears unlikely unless sufficient container cargo can be aggregated at adequate terminal facilities developed at a few major lake ports. Expansion of the Seaway's vessel size capacity through larger locks and deeper channels, equitable inland access, and an extended shipping season would also help attract full-containership services at Great Lakes load center ports. Manchester Lines, Ltd., British flag service, pioneered the first full-container service during the 1971 season.

Ocean-going barges, pushed, towed, carried, or self-propelled, appear to hold equal promise as full-containerships for Seaway service. Barges are more adaptable to the type and volume of cargo and the multiple port network of the present Great Lakes-overseas trade. Existing ocean-going barge concepts, such as the LASH and SEABEE barge carriers and the tug-barge combinations, are not suitable for Seaway use because of their size. Further studies may show that appropriate adaptations of these concepts for the Great Lakes-St. Lawrence system will prove to be economically and technically feasible.

One of the advantages of the barge carrying vessel is short turn-around time in port and flexibility of cargo types carried in its lighters and on deck. With the LASH and *Lykes* SEABEE systems, barges can be easily loaded and unloaded from the mother vessel at the rate of three or four per hour. The process requires no more than 24 to 36 hours in port. Many shippers state that because at least 50 percent of a ship's time is spent in port, barge carrying ocean ships can save an average of 20 days per voyage. The versatility of the barge carrier lies in its ability to carry all types of breakbulk, unitized, or bulk cargoes in its lighters in any reasonable mixture. The lighters can be towed to and from inland river and ocean port terminals for loading and discharging while the mother vessel continues to operate at sea.

The effect of lake wave action on the movements of these barges, especially LASH lighters, is another important factor that needs careful study. The occasionally strong currents and wave action of the Lakes are far different than those of an inland river channel or the oceans.

Recent unpublished research by Professor John Hazard of Michigan State University has revealed that the ocean-going barge carriers are more economical than either breakbulk general cargo vessels or full-containerships when serving multiple ports of call.

There are several potential methods and locations for operating ocean-going barge carrying ships and their lighters on the Great Lakes. Although existing barge carrier prototypes are too large to transit the Seaway, the mother ship could carry its lighters as far as Montreal where they could be transshipped to a feeder Great Lakes barge carrier or towed through the Seaway system. Another alternative would be to design a special barge carrier suitable for Seaway, ocean, and Great Lakes service. The operation and location of the mother ship and its lighters within the Seaway system can vary. Instead of the barge carrier calling at numerous lake ports, it could simply unload barges at various ports en route to Chicago, where it could load containers or heavy lift cargoes on deck, and then proceed to collect loaded barges on the back-haul. Alternatively, the mother ship could anchor at a location on any one of the five Lakes where it could load and discharge barges en route to and from several ports.

In addition to serving the Great Lakes through the Seaway, ocean barge carriers might receive lighters loaded at southern Lake Michigan ports to be towed down the Illinois and Mississippi River to the Gulf Coast. Ocean barge carriers could make Chicago a true year-round port with lighters moving down the Mississippi during winter and out the Seaway when it is open. See references 35 and 53 for more overseas fleet information.

4.4 Legislative Trends Pertinent to Great Lakes Navigation

4.4.1 Merchant Marine Program

The Merchant Marine Act of 1970 represents a notable milestone in the modernization of the United States Great Lakes fleet.[9] This Act designates the Great Lakes as the nation's fourth seacoast, and comes to grips with problems that have faced the industry for many years.

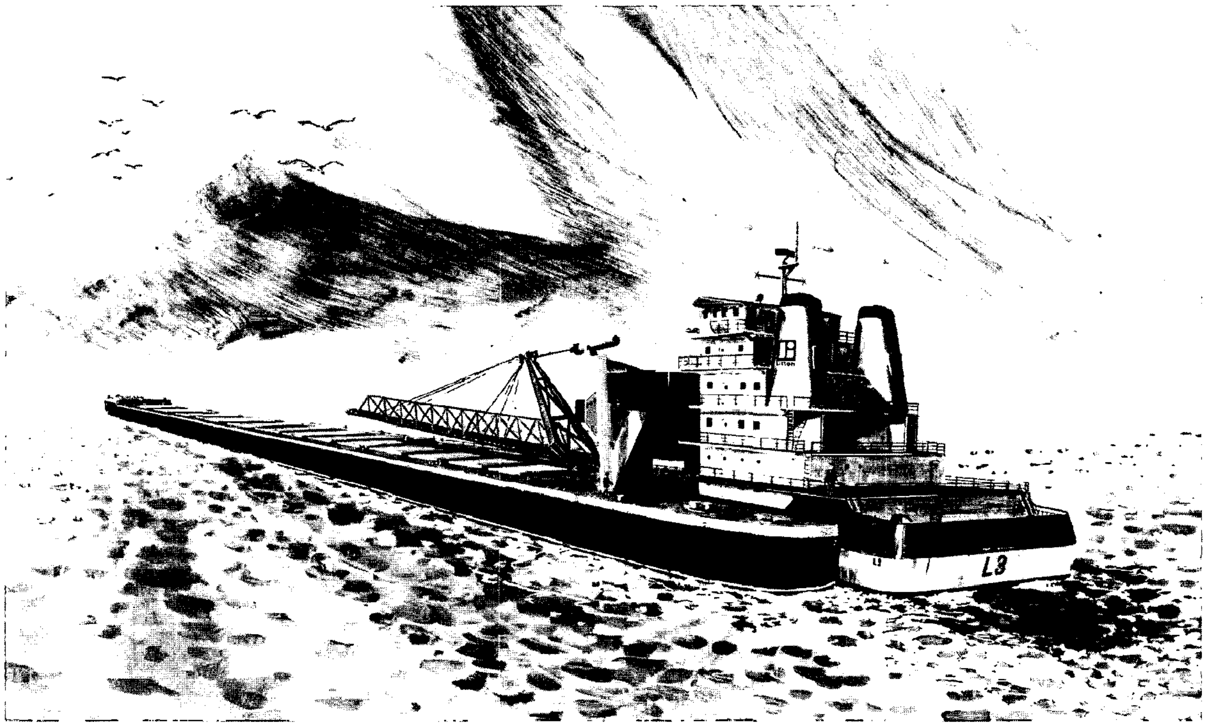
Most significant in the Lake carriers' view is the fact that the act allows creation of tax deferred construction reserve accounts for acquisition, construction, and reconstruction of lake vessels. This provision had been sought by the lake carriers for more than 18 years. It provides an incentive for vessel operators to replace their aging fleets, using funds that would otherwise have been paid in taxes. The past success of this incentive is well documented. Construction reserve accounts have been available to the ocean-going fleets for many years and have been largely responsible for the development of the most modern segment of the U.S. Merchant Marine, the liner fleet.

A number of new lake vessels are already being built and older vessels lengthened, e.g., the *Charles Beeghly* was lengthened from 700 feet to 806 feet with construction reserve accounts. As of February 1973, American shipbuilders were building five Great Lakes bulk carriers in their biggest shipbuilding program in any peacetime era. There were also contracts for construction of 175 barges and two towboats.

4.4.2 Environmental Control

The Federal Water Quality Improvement Act of 1970, among other things, is designed to protect Federal navigable waters from oil and sewage pollution from vessels.[9] The Act imposes liability, irrespective of fault, for the cost of cleaning up an oil spill up to $100 per gross ton of the vessel or $14 million, whichever is the lesser. The liability applies unless it can be shown that the spill was caused solely by an act of God, an act of war, negligence on the part of the United States, or an act or omission of a third party.

The Act provides that after giving appropriate consideration to the economic costs and technological limitations involved, Federal standards for the performance of marine sanitation devices shall be promulgated. These devices are to be designed to prevent the discharge of untreated or inadequately treated sewage into or on the navigable waters of the United States. The Coast Guard, in coordination with the Environmental Protection Agency, must promulgate regulations governing the design, construction, installation, and



Courtesy of Litton Industries

FIGURE C9-28 Artist's Sketch of 1,000-foot Tug Barge. Built by Litton Industries at Erie, Pennsylvania, this vessel was expected to begin service during the 1974 season.

operation of marine sanitation devices on board vessels. They are to be consistent with maritime safety and marine and navigation laws and regulations.

Standards and regulations are to become effective two years after promulgation for new vessels, and five years after promulgation for existing vessels. The Senate Committee on Public Works stated that marine sanitation devices should be installed at the earliest possible time permitted by existing and advancing technology, economics, and other practical considerations.

Congress recognized the necessity to relate sewage treatment control measures to the existing water quality control programs of the various States. It therefore authorized with the approval of the Secretary of the Interior (whose functions have since been transferred to the Environmental Protection Agency), the States to prohibit the discharge of any sewage from vessels, treated or not, in certain limited areas. But, according to the Senate Committee on Public Works, this authority is not to be broadly construed. "A State cannot prohibit vessel waste discharge from all of its rivers and lakes and coastal waters unless the State has, in fact, adopted standards which establish uses for all of those waters which require such an absolute prohibition. In effect, the Committee intends that any State prohibition apply only to areas for protection of public drinking water supplies, shellfish beds, and areas designated for body contact recreation."

Especially significant to Lake shipping is legislation relating to disposal of dredge spoil. Navigation improvements in the connecting rivers and channels must be achieved and maintained to realize the economies of waterborne transportation and to maximize the return from public investment in navigation facilities. This must be accomplished in coordination with environmental interests, as discussed in Section 5.

Legislation and local ordinances dealing with air and thermal pollution are also of immediate concern to vessel operators on the Great Lakes.

Because of the interstate and international nature of Great Lakes shipping operations, the method of imposing environmental controls, i.e., by local ordinance, State laws, Fed-

Courtesy of U.S. Army Corps of Engineers

FIGURE C9–29 Overseas General Cargo Vessels at Duluth, Minnesota, in 1969

eral laws, or by international agreement or treaty, is extremely important.

4.4.3 Shore Erosion and Shore Damage

Regulating the speed of vessels in connecting rivers has been a problem for navigation and shoreside property owners for many years. The speed required for steering control must be assured for safety of vessels and channels. Strict compliance with U.S. Army Corps of Engineers permit regulations for structures on the navigable waters is a possible solution to the problem that will become increasingly important as winter navigation becomes more routine and ice pressures on structures become more severe.

4.4.4 Navigation Safety

One of the most important pieces of marine safety legislation enacted this century is the bill signed by the President in August 1970 requiring bridge-to-bridge radio-telephone communication while vessels are operating in U.S. waters. Great Lakes vessels have been using this technique voluntarily since 1934. The new requirement will simplify meeting and overtaking situations with saltwater vessels not familiar with Great Lakes rules of the road.

Radio-telephone communication equipment requirements for bridges over navigable waters was authorized by regulations issued by the Coast Guard during 1970. Exchanges of intentions beyond the ranges of lights and horns will enhance the safety of both bridges and ships.

An important bill that would affect both navigation safety and environmental control is under consideration by Congress. It would authorize marine traffic control where justified, sea lanes, improved control of potentially hazardous ship design and operation, and establishment of standards for shoreside facilities to minimize hazards and pollution.

A uniform system of rules of the road at sea may present some problems for lake shipping even though a signatory nation can make exceptions for inland waters such as the Great Lakes. Recent statistics released by the Coast Guard show a 30 percent decrease of collisions on the Great Lakes during the past two decades. This compares with an increase of 360 percent on the oceans where international rules apply.

The National Transportation Safety Board has reported on a special study covering the six-year span 1963 to 1968, showing widely differing average fatality rates in freight movement by highway, rail, marine, and pipeline. The ratio between the most safe and the least safe method of surface freight transportation is approximately 1,000 to 1.

The averages were 10.9 deaths for every billion ton-miles in Federally regulated trucking, 2.5 in railroad freight carriage, and estimated .31 in commercial shipping, and .011 in petroleum pipeline movements. Statistics for non-regulated trucking and natural gas pipelines were not available for the study. In contrast to the large body of statistical data and analysis available on passenger safety, freight safety information was not readily available.

"One of the first requirements . . . in the shaping of national transportation policy is that the relevant data be available," the Board said. It recommended that the Department of Transportation regularly publish "comparable data on the losses and loss rates" in all freight transportation modes, including fatalities, injuries, property damage, and accident delays.

4.4.5 User Charges, Tolls, and Alleged Discriminatory Rail Rates

Legislative or administrative actions dealing with these important issues directly affect Great Lakes shipping. Each bill is studied by one or more Federal agencies, including Department of Transportation, Maritime Administration, and Interstate Commerce Commission. The impact of resulting or related legislation will have to be analyzed carefully by shipping interests.[13]

4.4.6 Codification and Simplification of the Shipping Laws

When the first Congress of the United States convened on March 4, 1789, the work of regulating shipping and navigation began. In fact, the need for uniform regulation of shipping and navigation was one of the compelling reasons for adopting the Constitution. In 1878 shipping laws then in existence were consolidated in the Revised Statutes. Since that time, the various statutes passed by the Congress have been included with the sections of the Revised Statutes in the United States Code. There has been no attempt to consolidate or rewrite conflicting provisions.

During the 92 years since enactment of the Revised Statutes, responsibility for administration of the shipping laws has been transferred eight times by implied amendment and reorganization, but the authorizing statute has never been expressly amended. Although need for codification of the shipping laws has long been recognized, it has proved virtually impossible because of the number of agencies involved in administering these laws. Now because virtually all statutory powers and duties contained in the shipping laws are vested in the Secretary of Transportation and administered through the Coast Guard, effective codification and simplification appears possible. If this can be accomplished, it will not only simplify the administration of the shipping laws but will reduce the burdensome paper work now imposed upon the vessel owner, particularly in connection with the documentation of seamen.

4.5 Energy Utilized per Ton-Mile

The energy cost per ton-mile for waterborne commerce is the lowest of the five principal modes of transportation (Table C9-82). In addition to saving energy, waterborne carriers primarily utilize trackless natural water courses to efficiently move great quantities of material without generating excessive noise,

TABLE C9-82 Ton-Miles Per Gallon of Fuel

Mode	Ton Miles Per Gallon of Fuel	BTU's Required Per Ton Mile[b]
Air	3.7[a]	6,300
Truck	58[a]	2,400
Rail	200[a]	750
Water		
(Inland River System)	250[a]	500
Pipeline	300[a]	Not Estimated
Typical Lake Vessel	495[c]	Not Estimated
Roger Blough		
858' Self-Unloader	656[d]	Not Estimated

[a]Estimated by Oak Ridge Laboratory, Tennessee, published in the Journal of Commerce 21 May 1973.
[b]Unpublished study by Rand Corporation.
[c]Estimated by Lake Carrier's Association, Cleveland, Ohio.
[d]Furnished by U. S. Steel Corporation for 16 trips with no cargo carried on backhaul.

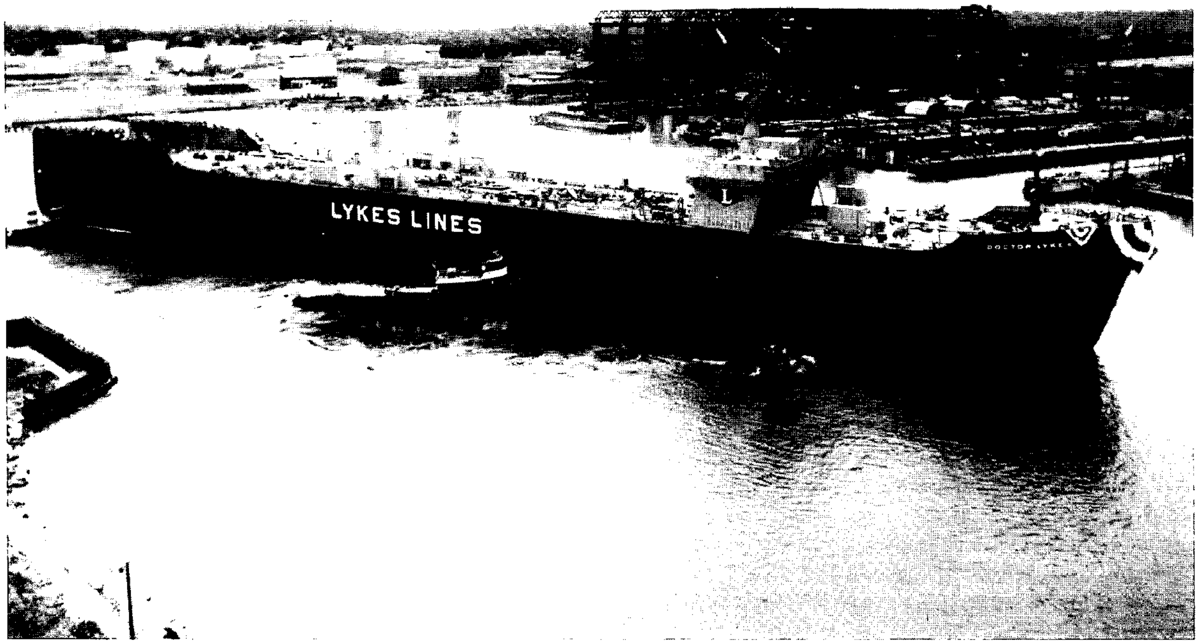


FIGURE C9–30 The *Doctor Lykes* SEABEE-Type Vessel. Approximately 24,500 long tons in thirty-eight 97-foot barges can be loaded into this vessel in only 13 hours. A conventional freighter would require a week or more to load that much cargo. The 36,000 horsepower engine produces a top speed of 20 knots. The ship will also carry 1,800 containers or roll-on/roll-off cargo. The SEABEE concept makes shallow harbors and inland waterways an integral part of a global transportation system.

preempting valuable land areas to the exclusion of other users, or altering great stretches of land. These characteristics are important considering environmental objectives, which include preservation of natural and cultural areas, duration or restoration of scenic areas, enhancement or protection to achieve or maintain quality of environment, and protection and rehabilitation of related land resources to ensure availability for their best use.

Back-haul cargoes have contributed to the low cost of waterborne transportation on the Great Lakes for the smaller vessels. For example, limestone from northern Lake Michigan and Lake Huron provides a back-haul for self-unloaders bringing coal from southern Lake Michigan and Lake Erie ports. Although larger vessels, especially the newer ones, are designed primarily for one way movement of a particular commodity, grain from Lakes Superior and Michigan, bound for Buffalo or Canadian ports along the St. Lawrence River, provides a back-haul for the vessels bringing Canadian iron ore into Lakes Erie and Michigan. Overseas general cargo vessels carry cargo both ways although export tonnage is 25 percent greater than import tonnage.

4.6 Environmental Considerations

The environmental effect of proposed projects concerning commercial navigation must be evaluated in an environmental impact statement (EIS) as required by the Environmental Policy Act of 1969.

Five items must be evaluated:

(1) environmental setting without the project

(2) environmental impacts of the proposed action

(3) any adverse environmental effects that cannot be avoided

(4) a relation between local, short term

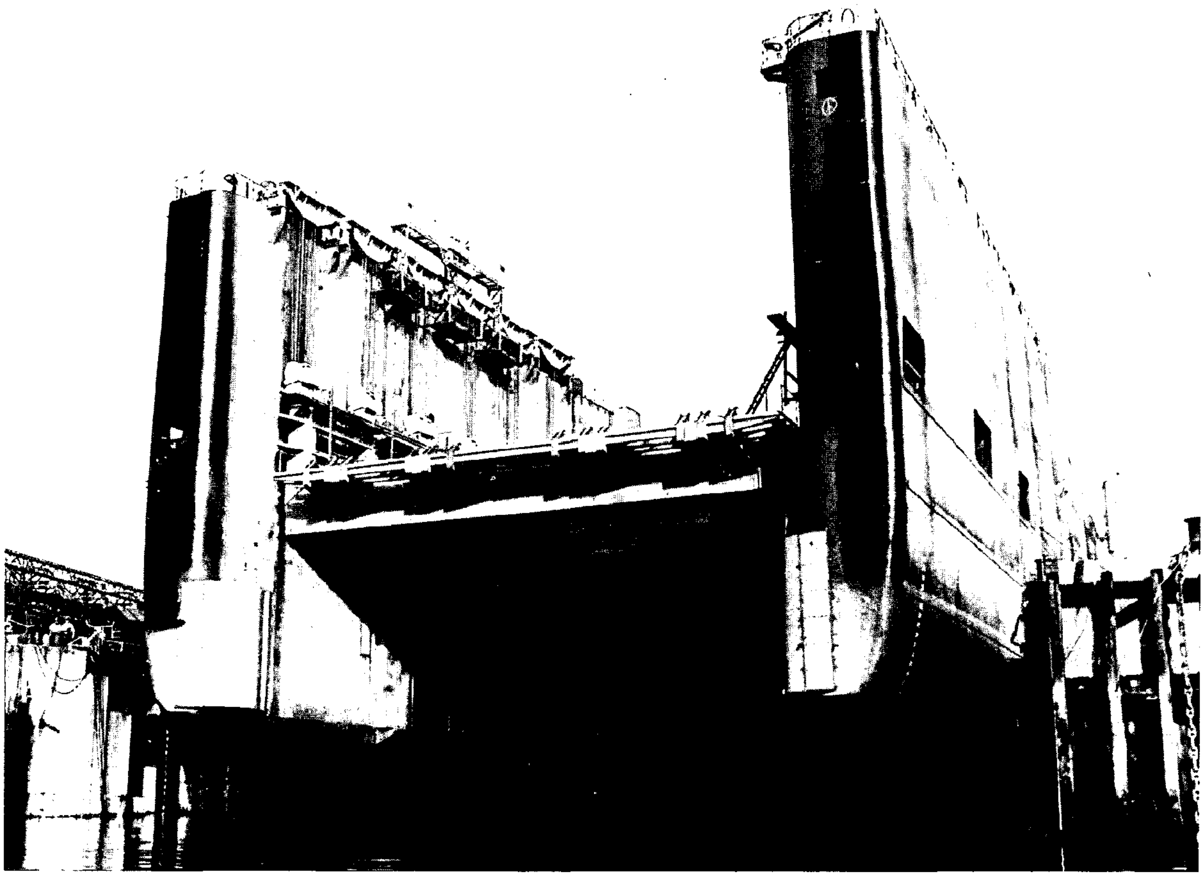


FIGURE C9–31 The World's Largest Shipboard Elevator. This view of the *Doctor Lykes'* stern shows the vessel's 21,000 ton capacity submersible shipboard elevator, the world's largest. This is the largest dry cargo ship afloat.

uses, and the maintenance and enhancement of long term productivity

(5) irreversible and irretrieveable commitments of resources

The purpose of an EIS is to insure that environmental consequences are known before any decision is made.

Because dredging is essential to the maintenance of the Great Lakes waterway system, the location and development of methods to dispose of dredged material should be the result of efforts by all concerned groups and agencies. As municipal and industrial waste treatment systems are fully developed, the problem of bottom sediment contamination is expected to diminish, thereby minimizing the impact of dredging on water quality.

The Corps of Engineers is presently engaged in a program that provides for diked disposal of any dredged material classified as polluted by the Environmental Protection Agency (EPA). The local cooperating agency is required to pay 25 percent of the additional cost to place the material in a diked area if EPA does not approve the local sewage treatment facilities. The disposal area must be sufficient to hold polluted materials expected to be dredged over a 10-year period. It has been assumed that in 10 years, sewage treatment facilities will be adequate to prevent continued pollution of harbor sediments so that dredged materials will no longer be polluted and require diked disposal. Material not classified as polluted may be deposited in approved areas in the Great Lakes.

The cost of diked disposal varies greatly from harbor to harbor, ranging from as low as 50 percent to as high as 500 percent or even 900 percent more than lake disposal. Cost varies with design, composition, and location of diked areas, techniques of handling material, treatment or other measures required, and relation of diking to land use planning. Although these factors vary widely from one location to another, diking is considered to be less costly than other means of handling dredging except lake disposal.

A pilot study recently completed by the Corps of Engineers indicated that construction of diked disposal areas to contain all dredged material from 35 Great Lakes harbors for a period of 10 years would cost approximately $70 million. The annual cost of dredging, including the cost of operation and maintenance for the diked disposal areas, would be increased from $5 to $10 million annually. In a 10-year period, costs would be increased from approximately $50 million to approximately $170 million if all 35 harbors were involved. This means overall costs would be increased 3 to 3½ times over current costs of lake disposal.

The need for diked disposal will be determined on a harbor-by-harbor basis as need for dredging arises.

The problem of inadvertent cargo and waste spills into the waterways are of great concern and are in need of further study. Systems should be developed to cope effectively with any occurrence.

Studies, conducted to determine baseline values for water quality in navigation waterways and harbors could be the basis for future monitoring, planning, and correction.

It is imperative that environmental considerations and restraints be used in the basic design criteria for all systems and components developed: harbors, terminal facilities, shore protection, and channel development.

4.7 Vessel Transits

4.7.1 General

As background information, the changing carrying capacity of the Great Lakes fleet is presented in Table C9-83. The number of vessel transits through the Welland Canal, the St. Lawrence Seaway, and the St. Marys River in recent years, and future transits based on the traffic projections in this report, are presented in Tables C9-84 and C9-86. The number of future transits is based on the existing channel and lock system. The system is not enlarged.

4.7.2 Average Cargo Per Transit

The maximum average cargo per transit through the Welland Canal in future years is estimated by first estimating the average ca-

TABLE C9-83 Carrying Capacity of the Great Lakes Fleet, 1958 to 1971 (Short Tons)

	U. S. Registry										Canadian	
	Dry Bulk[a]		Barge[b]		Package Freighters		Oil Tankers[c]		Total U. S. Registry		Canadian Registry	
Year	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity	No.	Capacity
1958	345	3,868,925	6	30,912	-	-	55	193,928	406	4,093,765	283	1,573,713
1960	322	4,045,440	6	30,912	-	-	55	194,264	383	4,270,616	258	1,661,962
1962	272	3,704,400	5	27,104	-	-	48	178,360	325	3,909,864	223	1,870,338
1964	238	3,365,712	5	27,104	-	-	49	170,520	292	3,563,336	215	2,118,082
1966	216	3,135,048	5	27,104	-	-	42	152,488	263	3,314,640	218	2,508,688
1968	205	3,020,584	5	27,104	-	-	40	144,424	250	3,192,112	181	2,487,184
1971	194	2,961,000	5	27,104	-	-	39	149,800	238	3,137,904	153	2,324,840

Source: Annual Reports, Lake Carriers Association--Section: "Carrying Capacity of the Lake Fleet".

[a]Bulk Freighters in iron ore trade; Bulk Freight, self-unloading vessels; Bulk Freight vessels in mixed trade.

[b]Bulk Freight Barges in mixed trades.

[c]Includes Barges.

TABLE C9–84 Tonnage and Transits Through Locks

	1953	1960	1962	1965	1970	1972
St. Marys Falls Canal (Soo Locks)						
Cargo, million tons	128.5	91.4	79.9	81.0	81.0	NA
Transits (+ 12 feet draft)	21,364	13,535	10,774	12,093	9,933	
Average cargo per transit (short tons)	6,020	6,750	7,420	6,700	8,160	
Transits (12 feet or less)	4,758	8,616	5,982	6,128	2,779	
Total transits	26,122	22,151	16,756	18,221	12,712	
Welland Canal						
Cargo, million tons	NA	29.2	35.4	53.4	62.9	64.1
Total transits		7,536	7,615	8,384	7,111	6,768
Average cargo per transit (short tons)		3,880	4,650	6,370	8,850	9,470
Ballast transits, % of total transits		30.8	30.0	25.6	28.0	27.9
St. Lawrence Seaway (Montreal to Lake Ontario)						
Cargo, million tons	NA	20.3	25.6	43.4	51.1	53.6
Total transits		6,869	6,351	7,330	6,277	5,936
Average cargo per transit (short tons)		2,950	4,030	5,920	8,150	9,040
Ballast transits, % of total transits		30.6	26.5	22.4	23.7	22.9

SOURCE: References 35 and 51.

pacity of the 1995 and 2020 Canadian vessel fleets, which comprise approximately 70 percent of the vessels transiting the Welland.

The average capacity of the 1995 fleet is estimated in Table C9–85. Because the system is assumed to remain the same size, the capacity of the class 10 vessels is redistributed to the class 4, 5, and 6 vessels. Average maximum vessel capacity is 23,500 short tons.

Analysis of statistics indicates that downbound vessels carried 42,969,000 cargo tons on the Welland canal in 1972 while upbound vessels carried only 21,126,000 tons. Therefore, vessels using the Welland are travelling at a maximum of 75 percent of capacity.

$$\frac{(42{,}969+21{,}126)}{(42{,}969\times 2)} = \frac{64{,}095}{85{,}938}$$

TABLE C9–85 Projected Average Vessel Capacity for Canadian Fleet in 1995

	Vessel Class							
	1	2	4	5	6	7	10	Total
No. of Vessel Equilavents	9.6	0.7	2.4	9.8	8.7	93.5	8.8	133.5
Average Capacity (1,000 tons)	4.35	9.39	13.6	19.3	26.0	27.0	62.0	--
Total Capacity	41.3	6.6	32.6	189	226	2525	546	3566
Redistribute Class 10 Capacity			100	200	246			
			132.6	389	472			3566
No. of Vessel Equilavents Required			9.8	20.2	18.2		0	3566
Average Capacity Per Vessel	3566 ÷ 152 = 23,500 short tons							

Analysis of ballast lockage statistics indicates that downbound vessels could probably carry at least 10 to 15 percent more cargo. This reduces the 75 percent to approximately 65 percent of capacity for the Welland. Therefore, average cargo per transit in 1995 would be 65 percent of 23,500 or 15,300 tons. Average cargo per transit on the Seaway (Montreal to Lake Ontario) has averaged approximately 95 percent of average cargo per transit on the Welland. This would be approximately 14,500 tons in 1995.

The 2020 Canadian fleet will be composed almost solely of class 7 vessels. Average carrying capacity of a class 7 is 27,000 tons at present Seaway depth. Because some other smaller ships will still be using the Seaway, an average cargo capacity per transit of 25,000 tons is used. Sixty-five percent of this is 16,200 tons. Ninety-five percent of 16,200 is 15,400 tons.

The projected average cargo per transit for the St. Marys Falls Canal is determined by assuming the 1971 value (8,660 tons per transit) increases at the same rate as the average cargo per transit through the Welland Canal.

Tonnages and transits through locks in recent years are presented in Table C9–84. The average cargo per transit is higher on the Welland Canal than on the Seaway (e.g., 9,470 tons compared to 9,040 tons in 1972), but because so many more large vessels transit the Welland Canal than the Seaway, the Welland traffic is actually less efficient. A higher percentage of vessel capacity is used on the Seaway than on the Welland.

4.7.3 Conclusion

Estimates in Table C9–86 represent the highest and lowest number of transits required to carry the medium projection of commerce through the locks in the Great Lakes-St. Lawrence Seaway.

Continued observation of shipping trends is necessary to determine the most efficient use of the Welland Canal and Seaway and to provide better estimates of when the system will reach capacity. Studies of capacity must address both absolute physical capacity and practical capacity. Cost of delays and other benefits must be weighed against the cost of constructing needed improvements.[29]

TABLE C9–86 Transits Required to Carry Prospective Commerce (Medium Estimate)

	1972 Average Cargo per Transit				Projected Maximum Cargo per Transit[a]			
	1980	1995	2000	2020	1980	1995	2000	2020
St. Marys Falls Canal (Soo Locks)								
Cargo, million tons	123	156	165	212	123	156	165	212
Transits (+ 12 feet draft)	14,200	18,000	19,000	24,400	10,800	11,200	11,600	14,300
Average cargo per transit (short tons)	8,700	8,700	8,700	8,700	11,400	14,000	14,200	14,800
Transits (12 feet or less)[b]	5,000	7,000	7,500	10,000	5,000	7,000	7,500	10,000
Total transits	19,200	25,000	26,500	34,400	15,800	18,200	19,100	24,300
Welland Canal								
Cargo, million tons	65	82	87	112	65	82	87	112
Total transits	6,900	8,700	9,200	11,800	5,200	5,400	5,600	6,900
Average cargo per transit (short tons)	9,500	9,500	9,500	9,500	12,500	15,300	15,500	16,200
Ballast transits, % of total transits	28	28	28	28	28	28	28	28
St. Lawrence Seaway (Montreal to Lake Ontario)								
Cargo, million tons	64	78	86	110	61	78	82	105
Total transits	7,100	8,600	9,500	12,100	5,100	5,400	5,600	6,800
Average cargo per transit (short tons)	9,100	9,100	9,100	9,100	11,900	14,500	14,700	15,400
Ballast transits, % of total transits	23	23	23	23	23	23	23	23

[a] See Subsection 4.7.2

[b] Estimated

Section 5

FRAMEWORK PLAN FOR ACTION

5.1 Framework Objectives

5.1.1 General

The area served by Great Lakes ports contains 35 percent of the nation's population, and provides 44 percent of the gross national product. The dispersion of mineral resources, population, and industry, and the Region's lack of large sources of energy contribute to the great need for a complete and efficient transportation system. Continued regional growth and development is dependent on such a system.

The basic objective of a framework plan is to provide a general guide to the best use, or combination of uses, of water and related land resources to meet foreseeable short- and long-term needs of a region. In studies to achieve this basic objective consideration is given to:

(1) the timely development and management of these resources as essential aids to the economic development and growth of the nation and the region

(2) the preservation of resources in appropriate instances to insure that they will be available for their best use as needed

(3) the well-being of the people as the overriding determinant in such planning

These broad economic and social goals can be divided into national economic development, regional development, and environmental quality.[56]

5.1.2 National Income Objective

The national income objective is best met by the most economical project (considering both benefits and costs) for developing a specific resource. Indicators as to whether the objective has been met include increased productivity of land, labor, and capital in the production of goods and services demanded by society, direct employment benefits resulting from utilization of unemployed or underemployed workers, and use of otherwise unemployed resources in related economic activities.

5.1.3 Regional Development Objective

This objective embraces increased regional income, increased regional employment, a broader economic base, improved income distribution within the Region, and improved quality of services within the Region.

5.1.4 Environmental Objective

This objective includes the preservation of natural and cultural areas, creation or restoration of scenic areas, and enhancement or protection to achieve or maintain the quality of the environment. Also included are protection and rehabilitation of related land resources to insure availability for their best use when needed.

5.1.5 Social Well-Being Consequences

All of the above affect social well-being in many ways such as health, national defense, personal income distribution, interregional employment, population distribution, and financial and physical security.

5.2 Framework Plan

The first step in developing a framework plan is to consider the known problems and constraints on development. These should be considered in terms of existing legislation, technological studies, and programs, and in terms of proposed programs, research, and study needs. Many problems facing commercial navigation on the Great Lakes are being addressed currently in several ongoing studies.

Following is a list of problems and constraints involving the development of commercial navigation:

(1) environmental effects:

(a) water level fluctuations

(b) disruption from navigation improvements

(c) vessel wastes

(d) oil spills and clean up

(e) air pollution

(2) structural and operational changes in the navigation system:

(a) additional locks of greater size along the Welland Canal and the St. Lawrence Seaway

(b) the channel depth and width needed to accommodate supercarriers

(c) extension of the navigation season and an ice information system

(d) hazards to commercial navigation, including congestion, currents, and recreational craft

(3) United States and Canadian coordination:

(a) water level fluctuations

(b) additional locks on the Welland Canal and the St. Lawrence Seaway

(c) tolls

(d) pilotage fees

(4) harbors:

(a) poorly protected berths

(b) entrance conditions

(c) maneuvering area

(d) depth

(5) terminal facilities:

(a) space for modern vessels and increased cargo

(b) slow turnaround

(c) poor management

(d) inadequate facilities

(e) conflicting land use

(6) other major problems or constraints:

(a) lack of port promotion and information

(b) lack of trained vessel personnel

(c) lack of repair facilities for superships

(d) lack of capital for investment in vessels

(e) capacity of existing lock systems (Soo-Welland-Seaway)

(f) competition

(g) containerization

(h) U.S. flag service on the Great Lakes

Alternatives or solutions to these problems and constraints include the following:

(1) legislation:

(a) Environmental Policy Act of 1969 (5-point statement)

(b) Water Quality Improvement Act of 1970

(c) Merchant Marine Acts

(d) International Joint Commission

(e) International Pollution Agreement

(f) 1970 Clean Air Act

(g) Federal Water Pollution Control Act Amendments of 1972

(2) studies and programs under way:

(a) Lake Erie-Lake Ontario Waterway

(b) additional locks on the St. Lawrence Seaway

(c) extension of the Season Demonstration Program and Survey Report

(d) widening and deepening of St. Marys River for 1,000-foot vessels (includes the Environmental Test Program)

(e) connecting channels and harbors study to accommodate 1,000-foot vessels

(f) Great Lakes Water Levels Study

(g) Corps of Engineers Survey Report and continuing Authorities Programs

(h) Department of Transportation U.S. Coast Guard Programs and Studies

(i) schools to train vessel personnel sponsored by the Lake Carriers Association and Dominion Marine Association

(j) local port development studies and programs

(k) Interstate Commerce Commission rate studies and proceedings

(l) urban renewal and Model Cities Program

(m) Maritime Administration studies and programs

(n) diked disposal areas program

(o) Department of Transportation rail freight rate and cargo feeder studies

(p) Pennsylvania State Study of Vessel Delay Costs

(q) Foreign Trade Studies, 1970 Bureau of Census

(3) technology:

(a) standardization of bulk vessel design

(b) continued vessel modernization and replacement of old vessels

(4) proposed programs, research, and study:

(a) regional or national marketing study preparation

(b) public relations program with quarterly or semi-annual report

(c) continued field study of thermal discharge effects

(d) more efficient seaway transit

5.2.1 Environmental Effects

Tools with which to evaluate the environmental effects of any modifications to the navigation system are available in the Environmental Policy Act of 1969 as amended and in the Water Quality Improvement Act of 1970.[41] In addition, the Corps of Engineers diked disposal area program and the environmental investigations for the various studies under way should alleviate the lack of information available on environmental effects. It is anticipated that environmental problems, such as disposal of dredged material, vessel wastes, and water level fluctuations, will be resolved through these Acts and programs (see references 15, 16, and 39).

The ultimate solution for polluted dredged material is to reduce or eliminate the amount of polluting material at its source by providing better municipal and industrial treatment. The 10-year time span for the present diked disposal program of the Corps of Engineers is based on the assumption that adequate treatment would eliminate the major sources of pollution in that time.

Such problems as risks of oil spills and public attitudes toward thermal pollution may in the long run have the greatest effect on the navigation industry. For example, the availability of power in the Great Lakes area may determine the rate of industrial growth, which in turn generates the ship traffic estimated in Section 3. There is a growing number of people who would contend that expanding technology and industrial growth and attendant environmental problems will ultimately cause the total downfall of civilization. On the other hand, there are those who contend that technology is the very tool that will solve the environmental problems that may perplex us today.

5.2.2 Structural and Operational Changes in the Great Lakes-St. Lawrence Navigation System

Most of the problems listed under this heading, especially extension of the navigation season, providing additional locks on the Seaway, and channel depth and width to accommodate super-carriers (vessels 730 feet to 1,000 feet long), are being addressed in ongoing studies. The questions to be answered by these studies are extremely important to the future of commercial navigation, as pointed out by the previous discussion of physical factors influencing navigation and as shown in the estimate of waterborne commerce that would move during the extended (from 8 to 12 months) navigation season (Table C9–87).

Extension of season for only Lakes Superior, Michigan, Huron, and Erie could result in traffic of 66,000,000 tons moving annually during the extended season by 2025. This would be primarily a redistribution of traffic that would move during the regular eight months season although it would include some new traffic. Additional needs includes better traffic control and reduction of hazards to navigation caused by congestion, currents, and recreational craft.

TABLE C9–87 Estimated Additional Waterborne Commerce from Extension of Navigation Season[a]

	1975	1985	2005	2025
Lime Ore	15	24	34	44
Limestone	1	3	5	6
Coal	5	6	8	9
Grain	0.1	0.3	0.4	0.8
General Cargo	0.05	0.3	0.5	0.6
Other	0.2	0.3	0.4	0.4
Total	21	35	51	66

[a]Estimated additional waterborne commerce in millions of tons from extension of the navigation season on the Great Lakes-St. Lawrence Seaway System from 8 to 12 months. Figures are for the four upper Lakes (Superior, Michigan, Huron, and Erie) only.

5.2.3 International Coordination

Because four of the Great Lakes and the St. Lawrence Seaway are international, coordination between the U.S. and Canadian governments is necessary. Such coordination is currently conducted under the auspices of the International Joint Commission. In spite of governmental reorganizations and differing goals and needs, the means for coordination is available and utilized. Coordination is also obtained through the several navigation organizations on the Great Lakes such as the U.S. St. Lawrence Seaway Development Corporation and the Canadian St. Lawrence Seaway Authority, the U.S. Lake Carriers Association, and the Canadian Dominion Carriers Association.

5.2.4 Harbors

Harbor problems such as inadequate depth, protection from storms, entrance conditions, and inadequate maneuvering areas are traditionally resolved through studies and project modification by the Corps of Engineers, by State or local action, or through improvements by the owners and operators of private harbors. Additional legislation or action is not required at this time.

5.2.5 Terminal Facilities

Existing terminal facilities are generally adequate for at least the near future with the possible exception of a need for a container port at the south end of Lake Michigan or at the west end of Lake Erie. It is recognized that many of the Hulett bulk unloading facilities are old, and replacement or rehabilitation may be necessary within a decade or so. The recent trend toward pelletization and self-unloaders, and possible pipeline transportation of coal slurry will also affect the need for such facilities. A 20 million ton coal loading facility is being constructed at Duluth-Superior to handle low sulphur western coal.

Another major consideration is the need for land for industrial expansion. Determination of land requirements, which is beyond the scope of this appendix, is affected by the following factors:

(1) extension of the season and reduction of stockpiling requirements

(2) trend toward supercarriers and resulting delivery of larger cargoes per trip

(3) trend toward increased pelletization and higher iron content

(4) possibility of transmission of coal and iron ore via pipeline or unit type trains

(5) costs of land and construction

(6) availability of labor force for plant operation

Although many factors are considered by industry when determining location and timing of expansion, a strong promotional effort by Great Lakes ports and shipping interests could promote growth in the area.

The relatively minor land requirements for navigation facilities (locks and channels) will be determined by ongoing studies such as "Additional Locks on the St. Lawrence Seaway", and "Connecting Channels and Harbors" studies.

5.2.6 Lack of Port Promotion and Information

Strong port promotion policies in conjunction with reviews of rate structures by the Interstate Commerce Commission, Department of Transportation, Maritime Administration could generate considerable interest in Great Lakes-Seaway transportation. Disseminated information should contain facts on shipping services available at ports and through the Seaway, their cost, shipping schedules, and total route times. This could be accomplished by information pamphlets and seminars for shippers.[17]

5.2.7 Lack of Trained Vessel Personnel

Although various classes conducted by the Lake Carriers' Association and the Northwestern Michigan College's Great Lakes Officers School assist in filling the shortage of trained personnel, a significant shortage remains. Continuation and expansion of these programs is essential. Efficient personnel are essential to the continued growth and efficiency of the Great Lakes fleet.

5.2.8 Lack of Repair Facilities for Superships

If the superships become as successful as anticipated, there may be a need for additional construction and/or repair facilities. Currently there are only two facilities on the Great Lakes capable of dry docking vessels in the 730 foot to 1,000 foot length. If, as anticipated, these docks are used for construction, there will be no facilities available for repair of existing vessels of this size.

5.2.9 Lack of Investment Capital for Construction of New Vessels

The construction reserve clause of the 1970 Merchant Marine Act will generate substantial new investment capital, to revitalize the U.S. fleet and promote improved shipping technology.

5.2.10 Competition

There is no easy solution to the multifaceted competition between various transportation modes, but rate studies and litigation now underway may provide partial solutions in terms of more equitable rail rates. Probably just as important as equitable rail rates is a positive attitude coupled with strong promotional activities by the major ports and shipping interests.

5.2.11 Containerization

Even though both conventional and smaller feeder container ships and break-bulk general cargo ships have sailed to and from Great Lakes ports, there is a lack of adequate specialized container-handling facilities on the Great Lakes and a lack of investment capital with which to build such facilities. There are only one or two areas that can generate sufficient containerized cargo to support full-containership service. Furthermore, interport competitive and political pressures may prevent development of modern regional container ports.

Further study is necessary to determine whether barge carrying vessels such as the LASH or SEABEE types, or large tug barges, can be adapted to the Great Lakes general cargo trade. See Subsection 4.3.4 for more detailed discussion of overseas general cargo.

5.2.12 Capacity of Existing Lock Systems

The capacities of existing lock systems in the St. Lawrence Seaway will be evaluated in the two studies "Additional Locks on the St. Lawrence Seaway" and "Lake Erie-Lake Ontario Waterway." A study of the capacity of the locks at Sault Ste. Marie is also needed. It is essential that studies of capacity consider the cost of delays in addition to pure physical capacity.[29]

5.2.13 Military Cargo

The substantial portion of U.S. military cargo generated in the area served by the Great Lakes does not move via the Lakes because of the requirement that it be shipped only in U.S. flagships. These are virtually nonexistent on the Great Lakes. Two solutions are immediately obvious: either allow shipment in foreign flagships or stimulate development of a U.S. fleet.

5.3 Time Factors and Regional Impact

The time when a factor begins to affect the system (based on time required to complete the study and any construction involved) is shown in Table C9-88. Items of immediate concern are extension of season, lock size, channel alignment, and depth at Sault Ste. Marie, channel alignment and depth through the St. Clair River, Lake St. Clair, and Detroit River, modernization of the vessel fleet, and increased efficiency throughout the system. The regional impact of alternatives in terms of the five major commodities is shown in Table C9-89 by placing an X under each planning subarea to or from which significant commodities are shipped. No impact is shown for Lake Ontario because planning subareas cover only the U.S. shore of the Great Lakes and very little cargo is handled at ports on the United States shore of Lake Ontario. It is obvious from examination of Tables C9-88 and C9-89 that extension of the navigation season has both the most immediate and most extensive impact on the total navigation system.

TABLE C9-88 Time Factor Effect on Great Lakes-St. Lawrence Seaway System

Factor	Immediate 1971-1980[a]	Long Range 1991-2020[a]
Season[b]	X	
Lock Size		
St. Lawrence Seaway[b]		X
Welland[b]		X
Sault Ste. Marie[c]	X	
Channel Alignment and Depth		
St. Lawrence Seaway		X
Welland (LELO)[d]	X	X
Sault Ste. Marie (St. Marys Falls Canal)[b]	X	
Detroit & St. Clair Rivers	X	
Vessel Fleet	X	
Increased Efficiency	X	
Port Promotional Efforts	X	
More Efficient Operation	X	
Better Traffic Control	X	
Extension of Season	X	

[a]Since all factors have either an immediate or a long range effect, there is no need to show a column for the period 1981-1990.

[b]Study under way.

[c]Poe Lock completed 1968.

[d]Realignment of the northern portion was completed in 1972, but greater depth is not expected until after 1991.

TABLE C9–89 Commodities Affected by Improvements

	Planning Subarea														
	1.1	1.2	2.1	2.2	2.3	2.4	3.1	3.2	4.1	4.2	4.3	4.4	5.1	5.2	5.3
Season Extension															
Iron Ore	x	x	–	x	–	x	–	–	x	x	x	x	–	–	–
Coal	x	x	x	x	x	x	–	x	x	x	x	x	–	–	–
Stone	x	x	x	x	–	x	x	x	x	x	x	x	–	–	–
Grain	x	–	–	x	–	–	–	–	–	x	–	x	–	–	–
Overseas General Cargo	x	–	–	x	–	–	–	x	x	x	x	x	–	–	–
Above Welland Canal															
Iron	x	x	–	x	–	x	–	–	x	x	x	x	–	–	–
Coal	x	x	x	x	–	x	x	x	x	x	x	x	–	–	–
Stone	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grain	x	–	–	–	–	–	–	–	–	–	–	x	–	–	–
Overseas General Cargo	x	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Between Lake Erie and Lake Ontario															
Iron	–	–	–	x	–	–	–	–	x	x	x	x	–	–	–
Coal	–	–	–	–	–	–	–	–	–	x	x	–	–	–	–
Stone	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grain	x	–	–	x	–	–	–	x	–	x	–	–	–	–	–
Overseas General Cargo	x	–	x	x	–	x	–	–	x	x	x	x	–	–	–
St. Lawrence River															
Iron	–	–	–	x	–	–	–	–	x	x	x	x	–	–	–
Coal	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Stone	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Grain	x	–	–	x	–	–	–	x	–	x	–	–	–	–	–
Overseas General Cargo	x	–	x	x	–	x	–	–	x	x	x	x	–	–	–

The function of the navigation system is to provide the most efficient transport of those commodities shown in Tables C9–90 through C9–93.

Because questions of further structural modification to the system will be answered by ongoing studies, the remaining question is how best to use the existing system. Following discussion of the system as a whole, a framework plan for each planning subarea is presented in Subsection 5.4.

5.4 Planning Subareas

5.4.1 General

Each of the 15 planning subareas will be discussed in terms of type and amount of commerce, value of commerce (money and jobs), cost of the navigation system, and problems or priorities. Shipments and receipts of bulk commodities by planning subarea are presented in Tables C9–90 through C9–93. Estimates of costs to improve the system are presented in Section 2, Tables C9–20 through C9–25. The income and employment generated by waterborne commerce in each planning subarea is determined in Table C9–94 by using estimated values of $5 and $24 per ton for bulk and general cargo, and applying an appropriate multiplier to develop total income generated (see references 34 and 36). These values ($5 and $24) represent the cost to a port of handling each ton of cargo. The number of families supported is determined by dividing total generated income by an estimated family income of $9,000 (1970). Assuming an average of 3.0 persons per family an estimate of population supported by bulk and general cargo commerce is found. However, it is important to recognize that some of the commerce is neither produced, manufactured, nor consumed in the planning subareas, but transported through them by rail or truck. Thus, the importance of bulk and general commerce is actually spread over a much larger area. On the other hand, in the major metropolitan areas of Chicago, Milwaukee, Detroit, Toledo,

TABLE C9-90 Percent of Shipments and Receipts by Commodity and Planning Subarea[a]

Planning	Iron Ore		Coal		Limestone		Grain		Overseas Gen. Cargo		Other Traffic	
Subarea	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.
1.1	63	--	--	8	--	3	25	--	12	1	--	
1.2	5	--	--	2.5	6	--	--	--	--	--	--	
2.1	--	--	--	5	--	1	--	--	2	--	--	
2.2	--	33	13	8	--	22	15	--	45	36	35	
2.3	--	--	--	--	--	--	--	--	--	--	--	
2.4	7	--	--	5	24	--	--	--	--	--	--	
3.1	--	--	--	1.5	46	--	--	--	--	--	--	
3.2	--	--	--	3	--	6	--	--	4	2	--	
4.1	--	10	--	30	--	33	--	--	18	26	10	
4.2	--	8	56	--	16	1	7	--	2	6	--	
4.3	--	33	30	--	--	19	--	--	7	15	13	
4.4	--	8	--	1	--	7	--	8	3	1	--	
5.1	--	--	--	--	--	--	--	--	--	--	--	
5.2	--	--	--	--	--	--	--	--	--	--	--	
5.3	--	--	--	--	--	--	--	--	--	--	--	
Subtotal	75	92	99	64	92	92	47	8	93	87	58	
Canadian	25[b]	8[c]	1[d]	36[d]	8[e]	8[e]	53[f]	74[g]	7[i]	13[i]	30	
Overseas	--	--	--	--	--	--	--	18[h]	--	--	--	
Total	100	100	100	100	100	100	100	100	100	100	88[j]	

[a] Based on 1969 and 1970 traffic and predicted traffic patterns from IJC Great Lakes Water Levels Study.
[b] 17% through Seaway, 2% from Georgian Bay, 6% from Thunder Bay.
[c] About 1½% to Sault Ste. Marie, 6% to Hamilton (Lake Ontario).
[d] About 1% shipped from Thunder Bay. Receipts: Sault Ste. Marie, Ontario, 5%; Lower Rivers, 5%; Lake Ontario, 25%; others, 1%.
[e] Mostly Canadian shipments on Lake Ontario.
[f] Canadian shipments from Thunder Bay.
[g] St. Lawrence River Ports, 63%; Georgian Bay, 5%; Toronto, 3%; others, 3%.
[h] Europe, 12%; United Kingdom, 3%; Japan, 1.3%; others, 1.7%.
[i] To or from Hamilton and Toronto.
[j] 12% not accounted for.

and Cleveland the importance of waterborne commerce is understated because several million tons of "other" traffic is not included in the analysis. A more rigorous analysis would include the higher-valued cargoes such as woodpulp, newsprint, and chemicals.

5.4.2 Planning Subarea 1.1 (Lake Superior West)

Taconite, Silver Bay, Two Harbors, and Duluth-Superior harbors in Planning Subarea 1.1 ship 63 percent of the iron ore traffic on the Lakes. In addition, Duluth-Superior ships 25 percent of the grain, 12 percent of the overseas general cargo, and handles scrap iron, fats, and oils in international trade, plus coal, limestone, salt, steel products, gypsum, and petroleum products in domestic movements. The bulk and overseas general commerce is expected to generate $935 million, $1.22 billion, and $1.6 billion in total (direct and secondary) income in 1980, 2000, and 2020, and could support 104,000 families in 1980 and 178,000 families by 2020 (assuming three persons per family and income of $9,000 per family; Table C9-94).

The volume of commerce, employment generated, and percent of total population that could be supported by the total income indicate that this planning subarea is highly dependent on the mining, processing, and shipment of iron ore and pellets, on the transship-

TABLE C9-91 Projected 1980 Shipments and Receipts by Commodity and Planning Subarea (Millions of Tons)

Planning Subarea	Iron Ore		Coal		Limestone		Grain		Overseas General Cargo		Total Traffic			
	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Other Traffic	Total
1.1	75	--	--	5.0	--	1.4	6.5	--	1.3	0.1	82.8	6.5	--	89.3
1.2	5.9	--	--	1.5	2.8	--	--	--	--	--	8.7	1.5	--	10.2
2.1	--	--	--	3.1	--	0.5	--	--	0.2	--	0.2	3.6	--	3.8
2.2	--	39	8.1	5.0	--	10.2	3.9	--	4.7	3.8	16.7	58.0	5.2	79.9
2.3	--	--	--	0.1	--	0.5	--	--	--	--	--	0.6	4.0	4.6
2.4	8.3	--	--	3.1	11.1	--	--	--	--	--	19.4	3.1	--	22.5
3.1	--	--	--	0.9	21.4	--	--	--	--	--	21.4	0.9	--	22.3
3.2	--	--	--	1.8	--	2.8	--	--	0.4	0.2	0.4	4.8	--	5.2
4.1	--	12	--	18.6	--	15.3	--	--	1.9	2.7	1.9	48.6	1.5	52.0
4.2	--	9.5	34.4	--	7.4	0.5	1.8	--	0.2	0.6	43.8	10.6	--	54.4
4.3	--	39	18.4	--	--	8.8	--	--	0.7	1.6	19.1	49.4	1.9	70.4
4.4	--	9.5	--	--	--	3.2	--	2.1	0.3	0.1	0.3	14.9	--	15.2
5.1	--	--	0.5	--	--	--	--	--	--	--	0.5	--	0.1	0.6
5.2	--	--	--	--	--	--	--	--	--	--	--	--	0.5	0.5
5.3	--	--	--	--	--	--	--	--	--	--	--	--	0.4	0.4
Subtotal	89.2	109.0	61.4	39.1	42.7	43.2	12.2	2.1	9.7	9.1	215.2	202.5	13.6	431.3[c]
Canadian	30	10	0.6	22.4	3.7	3.7	13.6	19.1	0.7	1.4	48.6	56.6	4.5	109.7
Overseas	--	--	--	--	--	--	--	4.6	10.4	10.5	--	4.6	--	4.6
Subtotal	119.2	119.0	62.0	61.5	46.4	46.9	25.8	25.8	10.4	10.5	263.8	263.7	18.1	545.6[c]
Total 1980 Traffic on[a] Great Lakes	118.7		62.0		46.4		25.8		10.5		278.2[b]		14.8	

[a] Subtotals and totals do not match because of rounding, small shipments or receipts not accounted for.

[b] Includes "other" traffic.

[c] Totals for subareas include both shipments and receipts (double counting) and therefore comprise more than the total 1980 traffic (278.2 million tons).

ment of grain, and on receipts and shipments of other bulk and general cargo. This traffic can only be sustained by a highly efficient and economical transportation system. A portion of the total income is generated by commerce originating outside of the planning subarea (e.g., grain), and therefore, the estimated total income is not confined to the planning subarea. The participation rate (employees/population) of 0.33 in 1960 and estimated at 0.37 in 1980 to 2020 is one of the lowest in the Great Lakes area and emphasizes the need to continue and improve the iron ore and transportation industries.

Federal expenditures through June 30, 1969 at Two Harbors and Duluth-Superior totaled \$27 million, including \$8 million for maintenance. Maintenance costs are now averaging more than \$200,000 annually. First costs and maintenance costs for private harbors are not available.

Provision of a 31-foot depth to accommodate full loading of supercarriers is not expected to require strengthening of dock structures, but it will require dredging costs as follows: Silver Bay, \$200,000; Taconite Harbor, \$600,000; and Duluth-Superior, \$17,000,000.

Priorities for this area are the extension of the season and accommodation of the new supercarriers, the *Roger Blough* and the *Stewart Cort*, which began service during 1972. Two additional 1,000 foot long ships are ordered for 1976 and 1977 to participate in the pellet trade between Lake Superior and Lake Michigan. Future waterborne traffic will be influenced positively by higher population and industrial growth (iron ore and copper industries), extension of season, use of superships in the Lakes above the Welland Canal, and strong port promotion policies. Low sulfur western coal has begun moving through Duluth-Superior harbor bound for the lower Lakes and may total several million tons annually by 1980.

Possible negative influences on waterborne commerce are lower growth rates for popula-

TABLE C9–92 Projected 2000 Shipments and Receipts by Commodity and Planning Subarea (Millions of Tons)

Planning Subarea	Iron Ore		Coal		Limestone		Grain		Overseas General Cargo		Total Traffic			
	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Ship.	Rec.	Other Traffic	Total
1.1	104	--	--	5.9	--	2.1	8.1	--	1.6	0.1	113.7	8.1	--	121.8
1.2	8.2	--	--	1.8	4.2	--	--	--	--	--	12.4	1.8	--	14.2
2.1	--	--	--	3.7	--	0.7	--	--	0.3	--	0.3	4.4	--	4.7
2.2	--	54	10	5.9	--	15.4	4.9	--	6.1	4.9	21.0	80.2	7.2	108.4
2.3	--	--	--	0.1	--	0.7	--	--	--	--	--	0.8	5.0	5.8
2.4	11.5	--	--	3.7	16.8	--	--	--	--	--	28.3	3.7	--	32.0
3.1	--	--	--	1.1	32.2	--	--	--	--	--	32.2	1.1	--	33.3
3.2	--	--	--	2.2	--	4.2	--	--	0.5	0.3	0.5	6.7	--	7.2
4.1	--	16	--	22.0	--	23.0	--	--	2.4	3.5	2.4	64.5	2.0	68.9
4.2	--	13	40.4	--	11.2	0.7	2.3	--	0.3	0.8	54.2	14.5	--	68.7
4.3	--	54	22	--	--	13.3	--	--	0.9	2.0	22.9	69.3	2.7	94.9
4.4	--	13	--	--	--	4.9	--	2.6	0.4	0.1	0.4	20.6	--	21.0
5.1	--	--	0.6	--	--	--	--	--	--	--	0.6	--	0.1	0.7
5.2	--	--	--	--	--	--	--	--	--	--	--	--	0.6	0.6
5.3	--	--	--	--	--	--	--	--	--	--	--	--	0.5	0.5
Subtotal	123.7	150.0	73.0	46.4	64.4	65.0	15.3	2.6	12.5	11.7	288.9	275.7	18.1	582.7[c]
Canadian	41.0	13.1	1.0	26.6	5.6	5.6	17.2	24.0	0.9	1.8	65.7	71.1	6.2	143.0
Overseas	--	--	--	--	--	--	--	5.8	All	All	--	5.8	--	5.8
Subtotal	164.7	163.1	74.0	73.0	70.0	70.6	32.5	32.4	13.4	13.5	354.6	352.6	24.3	731.5[c]
Total[a]	164.0		74.0		70.0		32.4		13.5		374.4[b]		20.5	

[a] Subtotals and totals do not match because of rounding, small shipments or receipts not accounted for.

[b] Includes "other" traffic.

[c] Totals for subareas include both shipments and receipts (double counting) and therefore comprise more than the total 2000 traffic (374.4 million tons)

tion and industry, transportation of ore by rail or pipeline, competition from foreign ores through eastern ports, and the Seaway (break-even point is now the Cleveland area).

Satisfying the national and regional economic development objectives will require continuation of the iron ore trade from western Lake Superior. There is sufficient iron ore reserve in Minnesota to last at least 100 years (Subsection 3.2.2).

5.4.3 Planning Subarea 1.2 (Lake Superior East)

Waterborne commerce in this area comprises shipments of iron ore from Marquette and limestone from Drummond Island, and receipt of coal at Marquette and Sault Ste. Marie. Additional commerce in petroleum products and miscellaneous items is received at the above ports and at Ontonagon. As shown in Table C9–94, approximately $102 million, $142 million, and $190 million of total income will be produced by this commerce in 1980, 2000, and 2020. This income could support 11,300, 15,800 and 21,100 families. This indicates that commercial navigation and other transportation modes are expected to play a more important role in the area's economy in future years. The present participation rate (employees/population) of 0.30 in 1960 is expected to rise to 0.35 in 1980, 0.37 in 2000, and 0.38 in 2020. This is attributed principally to increases in employment in the nonmanufacturing sector. Employment in manufacturing, mining, and agriculture is expected to decline (see Appendix 19, *Economic and Demographic Studies*).

Total Federal costs through June 30, 1969, at Marquette Harbor were $1,868,000. Maintenance costs have been very low—over the past five years an average of only 1,000 cubic yards annually have been dredged. Drummond Island harbor is a private facility and costs are not available.

Marquette Harbor would be considered for deepening to 31-foot depth at an estimated

TABLE C9-93 Projected 2020 Shipments and Receipts by Commodity and Planning Subarea (Millions of Tons)

Planning Subarea	Iron Ore Ship.	Iron Ore Rec.	Coal Ship.	Coal Rec.	Limestone Ship.	Limestone Rec.	Grain Ship.	Grain Rec.	Overseas General Cargo Ship.	Overseas General Cargo Rec.	Total Traffic Ship.	Total Traffic Rec.	Total Traffic Other Traffic	Total Traffic Total
1.1	139.0	--	--	5.9	--	3.1	9.7	--	2.0	0.2	150.7	9.2	--	159.9
1.2	11.0	--	--	1.8	6.2	--	--	--	--	--	17.2	1.8	--	19.0
2.1	--	--	--	3.7	--	1.0	--	--	0.3	--	0.3	4.7	--	5.0
2.2	--	73.0	10.0	5.9	--	22.8	5.8	--	7.4	6.0	23.2	107.7	9.2	140.1
2.3	--	--	--	0.1	--	0.8	--	--	--	--	--	0.9	6.0	6.9
2.4	16.0	--	--	3.7	25.0	--	--	--	--	--	41.0	3.7	--	44.7
3.1	--	--	--	1.1	47.7	--	--	--	--	--	47.7	1.1	--	48.8
3.2	--	--	--	2.2	--	6.2	--	--	0.7	0.3	0.7	8.7	--	9.4
4.1	--	22.0	--	22.0	--	34.0	--	--	3.0	4.3	3.0	82.5	2.6	88.1
4.2	--	18.0	40.4	--	16.6	1.0	2.7	--	0.3	1.0	60.0	20.0	--	80.0
4.3	--	72.0	22.0	--	--	19.7	--	--	1.1	2.5	23.1	94.2	3.4	120.4
4.4	--	18.0	--	--	--	7.2	--	3.1	0.5	0.2	0.5	28.5	--	29.0
5.1	--	--	0.6	--	--	--	--	--	--	--	0.6	--	0.2	0.8
5.2	--	--	--	--	--	--	--	--	--	--	--	--	0.7	0.7
5.3	--	--	--	--	--	--	--	--	--	--	--	--	0.6	0.6
Subtotal	166.0	204.0	73.0	46.4	95.5	96.0	18.2	3.1	15.3	14.5	368.0	362.2	22.7	752.6[c]
Canadian	55.0	18.0	1.0	26.6	8.3	8.6	20.7	28.8	1.2	2.0	86.2	84.0	7.9	178.1
Overseas	--	--	--	--	--	--	--	7.0	All	All	--	7.0	--	7.0
Subtotal	221.0	221.0	74.0	73.0	103.8	104.6	38.9	38.9	16.5	16.5	454.2	453.2	30.6	937.7[c]
Total[a]	221.0		74.0		103.8		38.9		16.5		481.5[b]		26.3	

[a] Subtotals and totals do not match because of rounding, small shipments or receipts not accounted for.

[b] Includes "other" traffic.

[c] Totals for subareas include both shipments and receipts (double counting) and therefore comprise more than the total 2020 traffic (481.5 million tons).

cost of $200,000. The estimated cost of deepening the channel through the St. Marys River to 31 feet is $317 million.

Waterborne commerce (iron ore and limestone) in this area would be benefited most by extension of season and improvements to the St. Marys River to accommodate the new superships. A technological break-through to allow prereduction of copper ore would greatly stimulate the area's economy.

5.4.4 Planning Subarea 2.1 (Lake Michigan Northwest)

Major harbors in this area are Green Bay, Manitowoc, and Kewaunee, which, in 1969 received 2.5 million tons of coal (1.8 million at Green Bay). Approximately one million tons of lumber, newsprint, pulp, and paper were shipped. Other commodities including petroleum products and building cement totaled approximately 3.8 million tons in 1969. All traffic is lakewise receipts or shipments with the exception of approximately 300,000 tons of overseas and Canadian imports and exports.

The bulk and overseas general cargo generates approximately $60 million, $75 million, and $81 million in total income in the area. This is sufficient to support approximately 2 percent of the population in the planning subarea. The "other" commerce (3.5 million tons in 1969) would very likely provide income to support approximately an additional 2 percent of the population.

Federal expenditures at these harbors have totaled $8.2 million, $2.6 million, and $9.7 million, for construction, rehabilitation, and maintenance. Recently maintenance, including 274,000 cubic yards of dredging, has averaged $360,000 annually (see Table C9-14). Harbors in this area are not likely to be deepened to 31 feet to accommodate the superships (classes 8, 9, and 10).

Primary functions of commercial navigation in this planning subarea are providing domestic general cargo transport to all harbors, providing bulk coal for a fossil fuel power plant and overseas general cargo at Green Bay for a substantial industrial and manufacturing community in that area, and shipping the products of local lumber and paper industries. The participation rate is expected to rise from 0.36 in 1960 to 0.38 in 1980 and 0.39 in 2020. Employment in agriculture will decline approximately 50 percent, and mining will be fairly constant, while manufacturing increases approximately 45 percent. Chemicals and paper industries will almost double their employment.

Neither the advent of superships nor extension of the season is expected to have a great influence on this area. The most effective means of continuing the present level of traffic or generating new traffic is stronger port promotion stressing dock capability, efficiency, and inland transportation capability.

5.4.5 Planning Subarea 2.2 (Lake Michigan Southwest)

Several major harbors are located in this area: Port Washington, Milwaukee, Oak Creek, Port of Chicago (includes Chicago Harbor, and Calumet Harbor and River), Indiana Harbor, Buffington Harbor, Gary Harbor, and the Port of Indiana (Burns Waterway). Combined, these harbors receive 33 percent of the iron ore, 8 percent of the coal, 22 percent of the limestone, and 36 percent of the overseas general cargo (imports). They ship 13 percent of the coal, 15 percent of the grain, and 45 percent of the overseas general cargo (exports). They ship or receive one-third of the other traffic on the Great Lakes.

According to 1970 figures, Calumet Harbor received 9.6 million tons of iron ore; Indiana Harbor, 9.9; Gary Harbor, 8.7; and the Port of Indiana, 1.5. Calumet Harbor and Calumet River handled 2.3 million tons of limestone; Buffington, 1.9; Indiana, 2.3; Gary Harbor, 1.3; and Port of Indiana, 0.3. Most of the coal, 6.3 million tons in 1970, was shipped via the Calumet River. A million tons were received at Port Washington, 1.7 were received at Milwaukee, and 1.2 were received at Oak Creek. Almost three million tons of grain were shipped from Calumet Harbor and Calumet River in 1970, while 0.8 million tons were shipped from Milwaukee. Most overseas general cargo, 3.9 million tons, was shipped from or received at Chicago Harbor and the Calumet River. The remaining one million tons was handled at Milwaukee.

Seaway trade at the Port of Milwaukee, which has heavy lift cranes of 85 and 200 tons capacity, has quadrupled since 1959. General cargo, export grain, import steel, and heavy lift machinery have been the major commodities. Other exports include agricultural implements, electrical apparatus, dairy products, chemicals and oils, paper, and forest products.

The Port of Chicago is the major overseas general cargo port on the Great Lakes. Major facilities are located at Navy Pier with spaces for six vessels and 500,000 square feet of storage area (385,000 under roof); Lake Calumet, with 5,300 feet of wharfage; and on the Calumet River. Grain elevators on Lake Calumet and Calumet River have a total capacity of 54 million bushels.

The 17-State midwest area served by harbors in Planning Subarea 2.2 account for one-half of the nation's marketed agricultural production and 45 percent of U.S. manufacturing value.

Bulk and overseas general cargo are estimated to generate $1.39 billion, $1.86 billion, and $2.36 billion in total income in 1980, 2000, and 2020 (Table C9–94). This is sufficient to support approximately 4.5 percent of the area's population. Total personal income in the area is estimated at $53 billion in 1980, $111 billion in 2000, and $231 billion in 2020 (1958 dollars), or approximately one-third of the total personal income in the entire Great Lakes Basin. The participation rate of 0.40 in 1960 (0.42 in 1980, 2000, and 2020) reflects the relatively high employment rate in this major industrial-manufacturing area and demonstrates the importance of a varied, complementary, and efficient transportation system.

Federal expenditures through June 30, 1969, have totaled approximately $44 million, $47 million, and $25 million for construction, rehabilitation, and maintenance. Average annual maintenance (492,000 cubic yards of dredging) now costs $710,000. This figure does not include estimated Federal costs of $13.6 million for construction and $100,000 for maintenance at the Port of Indiana (Burns Waterway), or costs for private harbors at Oak Creek, Buffington, and Gary. Estimated costs to deepen the major harbors to 31-foot depth are 95.9 million and 36 million for dredging and strengthening dock structures. As shown in Tables C9–24 and C9–25, most of the cost is for work at Milwaukee and at Calumet Harbor and River. Priority sites for accommodating superships, considering both traffic requirements and costs, are the Port of Indiana

TABLE C9–94 Port Income and Employment Generated by Waterborne Commerce for Port Handling Facilities and Related Services

Year	Planning Subarea	Income Multiplier[a]	Commerce (million tons) Bulk	General	Income (million $) Direct[b]	Total[c]	Employment Generated (families)[d]	Percent of Population Supported[e]
1980	1.1	1.9	86.9	2.4	492	935	104,000	85
	1.2	2.0	10.2	---	51	102	11,300	20
	2.1	2.6	3.6	0.2	23	60	6,670	1.8
	2.2	2.6	66.2	8.5	535	1,391	155,000	4.6
	2.3	2.0	0.6	---	3	6	670	0.07
	2.4	2.0	22.5	---	113	226	25,100	14
	3.1	2.0	22.3	---	112	224	24,900	46
	3.2	2.0	4.6	0.6	37	74	8,220	2.0
	4.1	2.0	45.9	4.6	340	680	75,600	3.9
	4.2	2.2	53.6	0.8	287	631	70,100	11
	4.3	2.2[f]	66.2	2.3	386	849	94,300	8.2
	4.4	2.2[f]	14.8	0.4	84	185	20,600	3.0
	5.1	2.2[f]	0.5	0.5[g]	3	7	778	0.24
	5.2	2.2[f]	---	0.3[g]	7	15	1,670	0.32
	5.3	2.2[f]	---	0.2[g]	5	11	1,220	1.6
	Total		397.9	20.8	2,478	5,396	600,128	5.4
2000	1.1	1.9	120.1	1.7	641	1,218	135,000	97
	1.2	2.0	14.2	---	71	142	15,800	27
	2.1	2.6	4.4	0.3	29	75	8,330	1.8
	2.2	2.6	90.2	11.0	715	1,859	207,000	4.5
	2.3	2.0	0.8	---	4	8	890	0.07
	2.4	2.0	32.0	---	160	320	35,600	16
	3.1	2.0	33.3	---	167	334	37,100	53
	3.2	2.0	6.4	0.8	51	102	11,300	2.1
	4.1	2.0	61.0	5.9	447	894	99,300	4.0
	4.2	2.2	67.6	1.1	364	801	89,000	10.8
	4.3	2.2[f]	89.3	2.9	516	1,135	126,000	8.6
	4.4	2.2[f]	20.5	0.5	114	251	27,890	3.3
	5.1	2.2[f]	0.6	---	3	7	778	0.19
	5.2	2.2[f]	---	0.4[g]	10	22	2,444	0.36
	5.3	2.2[f]	---	0.3[g]	7	15	1,667	1.9
	Total		540.4	24.9	3,299	7,183	798,099	5.7
2020	1.1	1.9	157.7	2.2	841	1,598	177,556	110
	1.2	2.0	19.0	---	95	190	21,111	33
	2.1	2.6	4.7	0.3	31	81	9,000	1.6
	2.2	2.6	117.5	13.4	909	2,363	262,556	4.5
	2.3	2.0	0.9	---	5	10	1,100	0.07
	2.4	2.0	44.7	---	224	448	49,778	19
	3.1	2.0	48.8	---	244	488	54,222	61
	3.2	2.0	8.4	1.0	66	132	14,667	2.1
	4.1	2.0	78.2	7.3	566	1,132	125,778	3.9
	4.2	2.2	78.7	1.3	425	935	103,889	10.0
	4.3	2.2[f]	113.4	3.6	653	1,437	159,667	8.7
	4.4	2.2[f]	28.3	0.7	158	348	38,667	3.8
	5.1	2.2[f]	0.6	---	3	7	778	0.15
	5.2	2.2[f]	---	0.5[g]	12	26	2,889	0.34
	5.3	2.2[f]	---	0.4[g]	10	22	2,444	2.4
	Total		700.9	30.7	4,242	9,217	1,024,102	5.8

SOURCE: Statistical Abstract of the United States 1971.

[a]See Subsection 5.4.1

[b]The sum of number of tons x $24/ton for general cargo and number of tons x $5/ton for bulk cargo.

[c]Direct income x income multiplier.

[d]Assume medium family income of $9,000. Total income ÷ $9,000 = number of families supported.

[e]Assuming population per household of 3.0. (Population per household has decreased from 4.9 in 1890 to 3.2 in 1970).

[f]The multiplier for Ohio is also used for Pennsylvania and New York.

[g]Canadian imports and exports.

(Burns Waterway), Gary Harbor, the outer portion of Indiana Harbor, and the outer portion of Calumet Harbor and River (lakeward of the first bridge).

The 1,000-foot-long self-unloader *Stewart Cort*, owned by Bethlehem Steel Company, began service in 1972 between Taconite Harbor and the Bethlehem docks at the Port of Indiana. The 858-foot long *Roger Blough* also began service in 1972 carrying pellets from western Lake Superior to southern Lake Michigan and Lake Erie ports. As stated in the discussion of Planning Subarea 1.1, two more 1,000 foot-long ships are on order for 1976 and 1977.

The economy of Planning Subarea 2.2 is dependent upon efficient transportation. Bulk commodities that sustain the steel industry, export grain, and general cargo must be received and shipped. Waterborne transportation not only has the capacity to meet the transportation needs of the planning subarea, but it is the most economical mode in terms of money and energy. It also pollutes less than the other available forms of transportation.

Strong port promotion and reduction or elimination of alleged discriminatory rail rates could substantially increase the area's share of grain exports and general cargo. Priorities are extension of the shipping season, accommodation of 1,000-foot vessels, and consideration of a container port.

5.4.6 Planning Subarea 2.3 (Lake Michigan Southeast)

Total lakewise traffic at the four harbors (Grand Haven, Holland, South Haven, and St. Joseph) in Planning Subarea 2.3 was 2.7 million tons in 1969. Approximately 0.4 million tons were limestone while approximately 1.3 million tons were lakewise shipments of sand, gravel, and crushed rock. Local traffic in sand, gravel, and crushed rock amounted to 2.0 million tons. Almost all sand and gravel traffic passed through Grand Haven.

The bulk commerce in coal and limestone is estimated to generate \$6, \$8, and \$10 million in total income. The large domestic and local traffic in sand, gravel, and rock (six million tons by 2020) will provide additional income of \$20 to \$30 million using \$3 to \$5 per ton for income generated. Income from waterborne commerce supports only one percent or less of the population in Planning Subarea 2.3. Approximately 56 percent of those employed in 1960 were in fields other than agriculture, mining, or manufacturing. This percentage is expected to increase to 72 percent by 2020.

5.4.7 Planning Subarea 2.4 (Lake Michigan Northeast)

The harbors in this planning subarea are Muskegon, Ludington, Manistee, Portage Lake, Frankfort, Charlevoix, Escanaba, Port Inland, and Port Dolomite. These harbors ship 7 percent of the iron ore and 24 percent of the limestone on the Great Lakes and receive approximately 5 percent of the coal. In addition, in 1969 more than 1.5 million tons of lumber, newsprint, wood and paper products, and approximatley 1.5 million tons of petroleum products were received. Bulk commerce is estimated to reach 22 million tons in 1980 and 44 million tons in 2020.

Total income generated by the bulk cargo traffic in iron ore, coal, and limestone is expected to reach \$226 million, \$320 million, and \$448 million in 1980, 2000, 2020 respectively. This income could support 25,000 families in 1980 and 50,000 families in 2020. The percentage of the planning subarea population supported by this income is expected to increase from 14 percent in 1980 to 19 percent in 2020. The expected growth of the chemical and paper industries, which will double employment between 1980 and 2020, while employment in agriculture and mining declines, is also expected to create increased demands for transportation. The participation rate is expected to increase rapidly from 0.33 in 1960 to 0.36 in 1980 and 0.39 in 2020, creating a need for efficient, economical transportation.

Federal expenditures for harbors in Planning Subarea 2.4 total \$11.0 million, \$3.9 million, and \$11.8 million for construction, rehabilitation, and maintenance. Maintenance averaging 267,000 cubic yards of dredging, cost \$365,000 annually from 1965 to 1969 (Table C9–14).

Escanaba is the harbor that will most likely be deepened to 31 feet to accommodate the 1,000-foot ore vessels. Costs are estimated at \$600,000 for dredging (Table C9–24). The estimated cost of deepening the Straits of Mackinac to 31 feet is \$23 million. Strengthening of port structures is not required. Although the harbors at Port Dolomite, Port Inland, and Muskegon may be deepened in the future, no cost estimates are available.

Priorities for this planning subarea are extension of the season, strong port promotion, accommodation of the needs of the growing chemical and paper industries, and provision for larger vessels when justified. Continuance of the limestone trade on the Great Lakes is dependent on the needs of the steel, construction, cement, lime, and chemical industries. Because limestone is a very low-value commodity, it is dependent on the continuance of complementary coal movements, which create a high load factor by using the same self-unloaders that carry the stone. Shipping cost comprises a major portion of the cost of limestone at receiving docks. Loss of cheap transportation would increase significantly the cost to the user.

5.4.8 Planning Subarea 3.1 (Lake Huron North)

The major harbors in this planning subarea are Calcite, Stoneport, and Alpena. Approximately 46 percent of the limestone traffic on the Great Lakes is shipped from this area (Table C9-90). Seven hundred thousand tons of coal or 1.5 percent of 1969 traffic were received at Alpena, while 2.3 million tons of cement were shipped from there. Other cargoes totaled approximately 500,000 tons in 1969.

As shown in Table C9-94, the bulk commerce in coal and in limestone is expected to reach 22.3, 33.3, and 48.8 million tons in 1980, 2000, and 2020. This will generate total income of \$224, \$334, and \$488 million, which will support 46, 53, and 61 percent of the planning subarea population. Assuming a value of \$15 per ton for cement, this commerce introduces another \$70 million in total income into the Alpena area in 1970 and probably more than \$100 million by 2020, employing approximately 10 percent of the population. The participation rate of 0.32 in 1960 is expected to rise to 0.36 by 1980 and 0.38 by 2000 and 2020, indicating a high growth rate for the area economy.

Because more than 50 percent of the area population is supported by industries producing or using large quantities of bulk commodities, the economy of the area is highly dependent upon an efficient, low-cost transportation system. This is especially true of the limestone trade, which is dependent upon complementary coal movements to produce a high load factor.

Expenditures have totaled \$0.8 and \$0.6 million for construction and maintenance of Federal harbors at Cheboygan and Alpena. Maintenance averages 33,000 cubic yards annually (primarily 25,000 cubic yards at Cheboygan), at an annual cost of \$26,000. Costs for private harbors at Calcite, Stoneport, Alpena, Port Gypsum, and Bayshore are not available.

Although improvements to accommodate supercarriers are not expected in the near future for the limestone and coal trades, they may become a reality later, depending upon market conditions. Only a few cement carriers are more than 500 feet long and draw more than 22 feet at midsummer draft.

The principal objective in this planning subarea should be extension of the season, increased efficiency, and close surveillance of the factors affecting the economics of transporting limestone, i.e., the complementary coal movement.

5.4.9 Planning Subarea 3.2 (Lake Huron South)

By far the principal harbor in this planning subarea is the Saginaw River. Principal receipts are limestone, coal, and general cargo. General cargo is also exported. Total shipments and receipts are projected to be 5.2, 7.2, and 9.4 million tons in 1980, 2000, and 2020. These figures will generate income to \$74, \$102, and \$132 million which is enough to support approximately 2 percent of the area population.

Expenditures to date at Saginaw River are \$13.1 million for construction and \$44 million for maintenance. Maintenance costs, including 500,000 cubic yards of dredging, are now averaging \$250,000 annually. The costs of accommodations for vessels greater than 730 feet are not estimated because these large vessels are not expected in this area in the foreseeable future.

Data in Appendix 19, *Economic and Demographic Studies*, shows that more than 99 percent of the work force in this planning subarea is heavily dependent on manufacturing and other industries for employment. There is very little dependence on agriculture and mining, although the limestone quarries and cement manufacturers are very important employers on a local basis. The number one priority for this area should be extension of season.

5.4.10 Planning Subarea 4.1 (Lake Erie Northwest)

This planning subarea contains one of the largest port complexes in the Great Lakes system, the Port of Detroit, which includes Rouge River and Trenton Channel. This area receives 10 percent of the iron ore, 30 percent of the coal, 33 percent of the limestone, and 26 percent of the overseas general cargo imports. It ships 18 percent of overseas general cargo exports. In addition, 10 percent of the other cargoes on the Great Lakes are shipped or received at the Port of Detroit. Total traffic is projected to be 52 million tons by 1980 and 88 million tons by 2020. This includes traffic received and shipped on the St. Clair River (mostly receipts of coal), which comprises approximately 15 percent of total traffic in the planning subarea.

This traffic is projected to provide \$680, \$894, and \$1,132 million in total income in 1980, 2000, and 2020, which will support approximately 4 percent of the area's population. The participation rate of 0.35 in 1960 is expected to increase to 0.40 in 1980 and remain at that level through 2020.

Expenditures at Port of Detroit have totaled \$76.6 million for construction and \$6.4 million for maintenance. Maintenance costs average \$571,000 annually. Dredging quantities average 550,000 cubic yards annually.

Costs to deepen the Port of Detroit to a 31-foot depth to accommodate vessels up to 1,000 feet long are estimated at \$11.4 million for dredging and at \$4.6 million for rebuilding dock structures. Costs to deepen the Detroit River, St. Clair River, and Channels through Lake St. Clair (\$367 million) are presented in Table C9–20. As shown in Table C9–23, a lock and dam may be required in the St. Clair River to control outflows from Lakes Michigan and Huron if the navigation channel is widened and deepened. This would create an additional delay and cost to navigation. The engineering feasibility and economics of navigating 1,000-foot ships through these channels to and from Lake Erie ports will be investigated in the Connecting Channels and Harbors Study, which is now underway and scheduled for completion in 1975.

Top priorities in the planning subarea are extension of season, strong port promotion (especially for overseas general cargo), encouragement of development of LASH-SEABEE type vessels for Seaway passage, accommodation of 1,000-foot vessels, and consideration of a container port. Problems facing commercial navigation interests are the possibility of transporting coal via pipeline and the success of Canadian National Railroad in capturing a significant portion of the overseas general cargo traffic.

5.4.11 Planning Subarea 4.2 (Lake Erie Southwest)

Toledo, Marblehead, Sandusky, and Huron are the major harbors in this planning subarea. These harbors ship 56 percent of the coal (approximately 40 percent from Toledo and 16 percent from Sandusky), 16 percent of the limestone, and 7 percent of the grain, and receive 8 percent of the iron ore and 6 percent of the overseas general cargo on the Great Lakes. Total traffic is estimated to reach 54 million tons by 1980 and 80 million tons by 2020.

The Port of Toledo is the third largest rail center in the United States, the largest bulk cargo port on Lake Erie, and the ninth largest in the country. A Foreign Trade Zone located at Toledo is serviced by a 125-acre port (land service area).

Traffic projected at this port is estimated to generate \$631 million, \$801 million, and \$935 million in total income for 1980, 2000, and 2020. These figures will support 10 to 11 percent of the area population. Participation rate is expected to increase from 0.36 in 1960 to 0.39 in 1980 and 0.40 in 2020. While total manufacturing employment increases 70 percent between 1960 and 2020, employment in the chemical and paper industries will more than triple. Employment in agriculture will decline to one-half its present value, while other employment will almost triple. Population will double.

Federal expenditures for the harbors above have totaled \$25 million, \$0.9 million, and \$19.2 million for construction, rehabilitation, and maintenance through June 30, 1969. Maintenance including 900,000 cubic yards of dredging, averages \$1.1 million annually. Costs for Marblehead harbor are not available.

Costs of providing a 31-foot depth to accommodate vessels up to 1,000-feet long are estimated at \$38 million and \$15 million for dredging at Toledo and Sandusky, respectively. Rebuilding dock structures in Toledo will cost an additional \$5.2 million. Costs of deepening at Marblehead and at Huron have not been estimated.

Priorities for this area are extension of season, strong port promotion, and accommodation of superships where necessary.

5.4.12 Planning Subarea 4.3 (Lake Erie Central)

Major harbors in this planning subarea receive 33 percent of the iron ore, 19 percent of the limestone, and 15 percent of the overseas general cargo imports. They ship 30 percent of the coal and 7 percent of the overseas general cargo, while handling 13 percent of the other traffic. The major harbor is Cleveland, which handles both bulk cargoes for heavy industry and general cargo with the help of its 150-ton capacity crane. The Port of Lorain is an expanding steel manufacturing center that receives ore, coal, and limestone as well as alloying materials from overseas sources. Planning Subarea 4.3 primarily receives waterborne commerce with the exception of coal and general cargo. Total tonnage is projected to reach 70 million tons in 1980 and 120 million tons in 2020. Traffic in 1969 totaled 61 million tons.

Projected traffic is estimated to produce $849 million in 1980 and $1.44 billion in total income in 2020. This is sufficient to support approximately 8 or 9 percent of the population. The participation rate of 0.38 in 1960 is projected to be 0.40 in the 1980 to 2020 period.

Expenditures in the area have totaled $68 million, $1.2 million, and $44.6 million for construction, rehabilitation, and maintenance. An annual average of 1.8 million cubic yards of material has been removed by dredging at a cost of $2.5 million annually.

Deepening to 31 feet to accommodate 1,000-foot vessels is estimated to cost $11.7 million for dredging at Lorain, Cleveland, and Conneaut, and $0.8 million for dock strengthening at Conneaut.

Priorities for this planning subarea are extension of the season, accommodation of 1,000-foot vessels, and strong port promotion. Competitive iron ore from the East Coast and possible shipment of coal by pipeline could present serious problems for commercial navigation in the future. Extension of the season and use of vessels up to 1,000 feet in length would enhance the economics of ore and pellets from western Lake Superior at the expense of foreign ores (Canadian, South American, and overseas).

5.4.13 Planning Subarea 4.4 (Lake Erie East)

Buffalo, New York, is the only major harbor in this planning subarea. It receives large quantities of iron ore, limestone, and grain. Bulk and general cargo traffic, which in 1969 totaled 17.1 million tons, is projected to be 15.2 million tons in 1980, 21.0 million tons in 2000, and 29.0 million tons in 2020. Eight percent or more of this traffic passes through the Port of Buffalo. Total income generated would reach $185 million in 1980 and $348 million in 2020, amounts sufficient to support 3 to 4 percent of the population in the planning subarea.

Expenditures for navigation through 1969 totaled $26.7 million, $0.3 million, and $19.2 million for construction, rehabilitation, and maintenance. Dredging quantities averaged 895,000 cubic yards at a cost of $806,000 annually from 1965 to 1969.

Deepening the harbor to accommodate vessels up to 1,000 feet in length is estimated to cost $13 million (800,000 cubic yards). An additional $1.8 million will be needed to rebuild port structures at Buffalo. The estimated cost of a new waterway between Lakes Erie and Ontario is $1.4 billion.

Priorities for this planning subarea are extension of season, port promotion, and accommodation of supercarriers.

5.4.14 Planning Subarea 5.1 (Lake Ontario West)

The only commercial harbor of significance in the planning subarea is Rochester, New York. Major commodities include lakewise receipts of non-metallic minerals (approximately 0.1 million tons annually). The traffic generates approximately $7 million of total income annually, which supports approximately 0.2 percent of the population.

Expenditures at Rochester have totaled $2.4 million for construction and $4.2 million for maintenance. Maintenance, (averaging 360,000 cubic yards dredged annually), costs $129,000 annually.

The most significant alternative or priority for this planning subarea is strong port promotion policies.

5.4.15 Planning Subarea 5.2 (Lake Ontario Central)

Great Sodus and Oswego are the commercial harbors in this planning subarea. No commerce has been reported at Great Sodus in recent years. Traffic at Oswego includes Canadian imports and lakewise receipts of cement and Canadian imports of fuel oil from the United States. The total income generated by the above traffic is estimated to be $15 million for 0.6 million tons in 1980 and $26 million for 0.8 million tons in 2020.

Expenditures in the area have totaled $9.0 million, $1.0 million, and $4.1 million for construction, rehabilitation, and maintenance. Recently, maintenance has averaged $95,000 for approximately 85,000 cubic yards of dredging.

The most significant alternative or priority for this planning subarea is strong port promotion to enhance the bulk and general cargo traffic with Canada and overseas.

5.4.16 Planning Subarea 5.3 (Lake Ontario East)

Ogdensburg on the St. Lawrence River is the only United States harbor of significance in this planning subarea. Traffic of 0.3 million tons in 1969 was composed of imports of pulp and newsprint from Canada and lakewise receipts of gasoline and fuel oil. Traffic is projected to reach 0.6 million tons by 2020. Total income generated by waterborne commerce is estimated at $11 million in 1980 and $22 million in 2020.

Expenditures for Ogdensburg harbor have totaled $646,000 and $730,000 for construction and maintenance. Maintenance has averaged $3,000 annually in recent years. The estimated cost of deepening the St. Lawrence Seaway to 31 feet is $0.9 billion.

The most significant alternative or priority for this planning subarea is strong port promotion to enhance the general cargo traffic with Canada and overseas.

SUMMARY AND RECOMMENDATIONS

Study of the present and prospective future of commercial navigation on the Great Lakes leads to three conclusions:

(1) The Great Lakes-St. Lawrence River commercial navigation system is a low-cost transportation facility essential to the economic vitality of the Great Lakes Region. Waterborne transportation requires less energy per ton-mile than any other form of transportation and creates very little noise and air pollution. It also provides efficient means of transporting energy sources such as coal. Innovations on the Lakes may include multiple barge towing to service customers with smaller delivered quantities.

(2) The Great Lakes-St. Lawrence River commercial navigation system is presently underused. A significant number of shippers do not avail themselves of the cost advantages of water transportation. The 19-State tributary area generates 20 to 25 percent of the nation's export/import general cargo traffic, one-half of which has a transportation cost advantage via the Great Lakes. However, only 7 percent is shipped via the Great Lakes. The 19-State area also produces 79 percent of U.S. grain, and the six midwest States bordering the Great Lakes produce 37 percent of U.S. grain. Only 15 percent is shipped via the Great Lakes.

(3) Additional system capacity is expected to be needed by about 1990. Recent studies indicate that the capacity of the existing Welland Canal and Seaway may be reached by about 1990. Additional capacity should be in place at that time. The 1970 Merchant Marine Act has stimulated modernization of the U.S. Great Lakes fleet. Vessel modernization and lengthening and new vessel construction programs have resulted from the 1970 Merchant Marine Act which declared the Great Lakes to be the nation's fourth seacoast and authorized a tax-free construction reserve to stimulate shipbuilding and modernization of the fleet. Several new large ships are being constructed under this new program. The total first cost (U.S. and Canadian) of providing the present 27-foot Seaway system from Montreal to Duluth was more than 2 billion dollars. Estimated costs (1967) to increase the system depth to 31 feet, 32 feet, or 34 feet are $3.5 billion, $5.0 billion, and $5.3 billion, respectively.

Based on the above conclusions, the Navigation Work Group has made the following recommendations:

(1) Every effort should be made to improve the efficiency of the present system. There will be a continuing need for observation, study, and improvement of system efficiency. The efficiency of the existing system can be improved by better traffic management through locks and critical reaches of channels, use of larger vessels, and extension of season. Efficiency will continue to be constrained by unbalanced traffic flow, i.e., more cargo moving in one direction than another, resulting in numerous ballast lockages on the return trip. Although tonnage per transit is rising and locks can handle more tonnage with the same number of lockages, there will be a continuing need for observation and study of lock efficiency, cost of delays, need for and cost of additional locks.

(2) Every reasonable effort should be made to extend the length of the navigation season. Due to adverse weather conditions, past shipping practices, and power booms, present navigation on the Great Lakes and the St. Lawrence Seaway has been restricted to a period that begins around the first of April and ends in mid-December.

(3) By 1980 as much as 80 percent of the present Seaway overseas bulk cargo fleet may be in need of replacement. This is primarily foreign flag service, and the United States has little control over design and development of new ships. Nevertheless, this provides an excellent opportunity to construct new vessels designed specifically for the Seaway system. The primary features of these ships should be adaptability and flexibility. In addition to breakbulk and palletized cargoes, they should be capable of carrying standard containers, roll-on roll-off cargoes, bulk grains and liquids, and other dry and refrigerated commodities.

(4) Channels and dock facilities should be modified if necessary to accommodate vessels

of 730 feet to 1,000 feet in length. Two vessels of this size are now in operation on the Great Lakes above the Welland Canal. The St. Marys River is being widened at bends to accommodate 1,000-foot-long vessels in connection with the ongoing Great Lakes Connecting Channels and Harbors Study. The 1,000-foot-long *Stewart Cort* averaged about 55,000 short tons per trip in the 1972 season, more than double the capacity of the 730-foot-long vessels which are the maximum size that can fit through the St. Lawrence River and the Welland Canal.

(5) The efficiency of handling general cargo on the Great Lakes must be improved.

(6) A reorganization of regulations and subsidies governing all modes of transportation could reduce or even eliminate subsidies of each mode to compete with the others. The reorganization would allow each transportation mode to move the cargo it is best equipped to handle.

(7) Use of the same waters by both commercial and recreational traffic should be avoided where possible.

(8) Technological improvements should be developed to provide a greater stimulus to the Great Lakes, especially to specific regions. These improvements may include prereduction of copper ore or iron ore, development of a feeder system for containerized cargo, increased standardization of bulk vessel designs, more efficient loading and unloading systems (faster turnaround time), and more efficient traffic control and lock operation.

(9) Eliminating alleged discriminatory rates and strengthening port promotion activities could enhance use of the Great Lakes system by marginal traffic and traffic now using other modes of transportation because of habit or current rates. Promotion activities could include issuing a newsletter several times a year and holding meetings or conferences for prospective users.

(10) The growth and prosperity of the Great Lakes-St. Lawrence Seaway system requires the cooperating efforts of both the Canadian and United States governments to assure the best use and preservation of this valuable resource.

(11) The existing system will require additional lock and channel capacity by about 1990.

(12) An effective framework plan for the Great Lakes must provide for timely completion of ongoing studies (priority funding and completion efforts), and continual evaluation of technological innovations such as pipeline shipment of coal or ore.

(13) There is a need for highly efficient, load center, full containership, general cargo ports on the Great Lakes. However, it appears that there are only a few areas that could generate sufficient container cargo to support full containership operations.

(14) An international regional study of the entire Great Lakes-St. Lawrence River commercial navigation system is needed.

GLOSSARY

anchorage area—that portion of a habor (or the designated area outside a harbor) in which ships are permitted to lie at anchor.

aid to navigation—a device external to a craft, designed to assist in determination of position, a safe course, or to warn of dangers or obstructions: lighthouses, offshore light structures, buoys, day-beacons, long-range electronic aids (LORAN), short-range radio beacons, and fog signals.

bale cubic—the number of cubic feet of space available on a ship for baled or packaged cargo. The measurement is taken to the inside of the cargo battens, on the frames, and to the underside of the beams.

ballast—stone, rock, water, or other material placed in an empty or lightly loaded ship for the purpose of steadying it in rough seas. Ballast is not considered ship's stores and it is assessed the same charges as cargo.

basin, turning—an enlargement of a channel in which vessels can turn around.

berth—the water area at the waterfront edge of a wharf reserved for a vessel.

breakwater—an engineering structure to afford shelter from wave action; may be called mole, jetty.

bulkhead—a wall, either watertight or with passages, separating cargo or living spaces in a ship.

bulkhead line—boundary set by governing body beyond which solid fill may not be extended. An exception is made when fill is placed within the confines of a pier extending out from the bulkhead line.

buoy—a floating object, other than a lightship, moored or anchored to the bottom as an aid to navigation.

cabotage—restriction of transport within the boundaries of a country to domestic carriers.

car ferry—a vessel provided with tracks upon which railroad cars may be transported over water (may also carry automobiles).

cargo deadweight—this is the number of tons of 2,240 pounds that remain after deducting from the vessel deadweight the weight of fuel, water, stores and other items necessary for use on a voyage. It represents the total weight of cargo that will bring this particular vessel down to its maximum permissible draft.

cargo weight—the difference between gross weight and tare weight of the container.

channel—the buoyed, dredged and policed fairway through which ships proceed from the sea to their berth from one berth to another within a harbor.

coastwise receipts and shipments—domestic traffic carried over the ocean or the Gulf of Mexico, e.g., New Orleans to Baltimore or New York to Puerto Rico. Traffic between Great Lakes ports and seacoast ports, when carried over the ocean, is also termed "coastwise".

cofferdam—a temporary structure for the exclusion of water from a site during construction. On a ship, a void space between two watertight bulkheads.

commodity stowage factor—the number of cubic feet occupied by one weight ton of a particular commodity, including container.

container (cargo)—an enclosed, permanent, reusable, nondisposable, weather-tight shipping conveyance, fitted with at least one door, and capable of being handled and transported by existing equipment and modes of land and sea transport. For marine containers, common lengths are 10, 20, 24, 30, 35 and 40 feet.

containership—a vessel designed for carrying containerized cargo. A full containership carries only containerized cargo. A partial containership can also carry bulk cargoes.

container capacity—the inside cubic volume of the container (l × w × h).

containerization—practice of storing and shipping small packages, boxes, bulk materials within a box-like structure.

crane, cargo—a crane especially adapted to the transferring of cargo between a vessel's hold and a wharf or lighter vessel.

datum—reference point for elevations of structures and water level. Elevations on the Great Lakes are in feet above mean water level at Fathers Point, Quebec, on the St. Lawrence River.

deadweight tonnage—the term "total (vessel) deadweight" is used to express the total weight-carrying capacity of a ship including cargo, fuel, oil, fresh water stores, and crew. It is the difference between displacement loaded and displacement light. "Cargo deadweight" is used to express the cargo carrying capacity of the ship. "Vessel stowage factor" and "commodity stowage factor" are used to express the relationship of ship space to cargo weight. In order to make this clear, the following example, using the weights with respect to a typical freighter together with supplemental definitions, is presented.

	tons
displacement, loaded	10,500
displacement, light	3,290
deadweight tonnage	7,210
fuel, water, stores, etc.	1,210
cargo deadweight	6,000

demurrage—the delaying of a ship, freight car, etc., by the failure to load, unload or sail within the time allowed. Also refers to the compensation paid for this.

displacement, light—the weight, in tons of 2,240 pounds, of the vessel excluding cargo, passengers, fuel, water, stores, dunnage and other items necessary for use on a voyage.

displacement, loaded—the weight, in tons of 2,240 pounds, of a vessel including cargo, passengers, fuel, water, stores, dunnage, and other items necessary to bring the vessel down to its maximum permissible draft.

dock, dry—Several types of dry dock are described below:

(1) Floating dry dock is buoyant structure or hull open at both ends capable of being flooded and sunk to controlled levels and pumped out and raised, into which ships may be shifted in order to lift them out of the water for repairs.

(2) Graving dry dock is a dock into which a ship is floated for cleaning and repairs. It is fitted with gates which when closed permit the dock to be pumped dry.

(3) Gridiron dock is one where a cluster of piles with caps, or stringers on to which a barge may be floated at flood tide and which, with the fall of the tide, holds the barge at a certain level permitting connection with land tracks and allowing railroad cars to run on to the barge for ferrying.

(4) Hydraulic lift dock consists of a horizontal platform of pontoons, upon which a vessel can be floated.

(5) Slip dock is a marine railway which enters a chamber with side walls and water gate, the floor of which is at low water level to permit hauling out a vessel at high tide, gates being closed at low tide to lay the vessel dry. The slip dock can be applied only where there is a considerable range of tide. It was evolved to permit a shortening of the underwater portions of the railway and to avoid excessive length where the shore is high.

dock, wet—a basin in which the water is maintained at a fairly level depth by closing gates when the tide begins to fall.

dolphin—an isolated cluster of piles used as a support for mooring devices or marker lights.

dredge—a machine for excavating material from the bottom of a body of water, classified by type of excavating equipment used such as bucket, dipper, ladder, hopper, or hydraulic dredges.

dry cargo bulk—commodities customarily loaded and carried without wrappers or containers, and received and delivered without transportation mark or count whether such cargo is handled on berth terms, voyage charter, or any other basis.

dry cargo general—miscellaneous goods packed in boxes, bags, bales, barrels, crates, drums, unboxed or uncrated, accepted and delivered by mark and count.

dunnage—a loose packing of bulky material put around cargo for protection (also personal baggage or belongings).

elevator, grain storage—structure for receiving, cleaning, conditioning, handling and shipping grain.

export or outbound tonnage—cargo, including that destined for transshipment or reexport, loaded at a United States port for discharge at a foreign port.

free port—an area generally encompassing an entire port and its surrounding locality, into which foreign goods may be brought without imposition of customs duties if they are intended for reexportation or for local consumption. Free ports in less developed parts of countries tend to be multi-purpose facilities simultaneously accommodating local and international commercial activities, industry, and tourism.

free trade zone—an enclosed, policed area in a seaport or at an airport or other inland point treated for customs purposes as lying outside the customs territory of the country. Foreign goods may be brought in pending eventual transshipment, reexportation, or importation into the local market, without payment of customs duties. Domestic goods intended for export or for admixture with foreign goods may also be brought into the free trade zone.

grain cubic—the maximum number of cubic feet of space on a ship available on a ship for grain or other dry bulk cargo. The measurement is taken to the inside of the shell plating of the ship and to the underside of deck plating.

gross ton—2,240 lbs. (short or net ton = 2,000 lbs.)

gross tonnage—the entire internal cubic capacity of a ship, except for certain spaces such as inner bottom tanks, peak and other tanks for water ballast, open forecastle bridge and poop, shelter deck spaces, excess of hatchways, certain light and air spaces, domes and skylights, wheelhouse, galley, cabins for passengers, and certain other spaces, expressed in tons of 100 cubic feet.

gross weight—the total weight of the container and the cargo.

harbor—an area affording a natural or artificial haven for ships. In a proper and more limited sense, an area separated from the main body of water, by natural or artificial indentations of shoreline such as the area within two headlands.

harbor facilities—those aids, advantages or conveniences provided for ships as distinguished from those provided by the port for cargo or passengers. This term includes channels, anchorages and anchorage basins, mooring posts, dry docks, ship repair plants, tug boats, car floats, lighters and ferries.

harbor limit—boundary line of area set aside for harbor development, established by competent authority, beyond which construction (docks, etc.) is prohibited.

inbound and outbound—traffic moving from one waterway into another is termed "outbound" in the case of the shipping waterway and "inbound" with respect to the receiving waterway.

integrated transportation—the combination of various transport modes through the use of standard interchangeable units. This allows for door-to-door delivery with a minimum of cargo handling and maximum speed.

internal receipts and shipments—these terms apply to traffic limited to ports or landings on inland waterways.

import or inbound tonnage—cargo, including that for transshipment or reexport, loaded at a foreign port for discharge at a United States port.

jetty—an engineering structure at the mouth of a river or harbor, or elsewhere, to control the waterflow and currents, to maintain depth of channel, or to protect harbor or beach.

lakehead—refers to the western end of Lake Superior especially Duluth-Superior.

lakewise receipts and shipments—these terms apply to traffic between United States ports on the Great Lakes system. The Great Lakes system is treated as a separate system rather than as a part of the inland system.

leading light(s)—a light or lights arranged to indicate the path to be followed.

lighter aboard ship—an adaptation of the containership idea in which lighters (small barges) are carried aboard a mother ship and when unloaded can travel to many different ports. The *Arcadia Forest* is an example. It carries 73 lighters, each lighter is 31 feet wide and 615 feet long.

limnology—the scientific study of biological, chemical, geographic, and physical features of fresh waters, especially lakes and ponds.

liquid cargo, bulk—commodities in liquid form transported in tankers or in deep tanks of dry cargo ships.

local traffic—movements of freight within the confines of a port whether the port has only one or several arms or channels. This does not include car-ferry and general ferry traffic. The term also applies to marine products, sand and gravel taken directly from the Great Lakes.

lock—the system of valves, wet docks, and watergates permitting ships to pass from a higher to a lower or a lower to a higher water level.

long ton—2,240 lbs.

lower lakes—refers to the lower end of Lake Michigan and to Lakes Erie and Ontario.

low water datum—the reference plane established for each of the Great Lakes.

marine railway—track, cradle, and winding mechanism used to draw ships out of the water onto the bank for the purpose of inspection and repair.

mean level (sea and lake)—the average height of the sea or lake, determined by averaging the hourly heights of the water surface for a period of time.

measurement ton—in the foreign trade of the United States the measurement ton is considered to be 40 cubic feet.

net ton—2,000 lbs.

payload—the weight on which the tariff is based.

pier—a structure or platform of timber, masonry, earth or other material, usually built at right angles to the shoreline of the harbor and extending outwards to deep water, permitting vessels to lie against it to discharge or receive cargoes or passengers.

pier head line—line set by the U.S. Army Corps of Engineers, or other competent authority beyond which the pier may not extend. (There is also a pier head line coincident with the actual pier heads, or established by the local port authority.)

port—a harbor provided with terminal and transfer facilities that enable it to be used in commerce. As distinguished from the term harbor, port involves some degree of development for purposes of commerce. If there are no marked indentations of shore lines, ports may exist without harbors.

port authority—the administrating committee or board of directors of a designated port area vested with the control and administration of certain designated waterfront property.

port facilities—waterfront terminals, including structures, reservations, equipment, appliances, and necessary collateral aids or conveniences for embarking and disembarking passengers and commodities transported or to be transported by water. This includes wharves, piers, sheds, warehouses, railroads, water or street connections, belt railroads and yards, and handling appliances.

radio beacon—a radio transmitter which emits a distinctive or characteristic signal used for the determination of bearings, courses, or location. One intended primarily to mark a specific location is called a marker radio beacon.

range lights—two or more lights in the same horizontal direction, particularly those lights placed as navigational aids to mark any line of importance to vessels, such as the axis of a navigable channel. The one nearest the observer is the rear light.

revetments—engineering structures to protect from erosion and to hold in place banks of canals, rivers and harbors.

riparian rights—the rights of a person owning land containing or bordering on a watercourse or other body of water in or to its banks, bed, or waters.

SEABEE—another adaptation of the containership idea in which barges are carried aboard a mother ship. The *Doctor Lykes* is an example.

service—the means of providing transportation over a trade route, including the itinerary, sailing frequency, number and type of vessels to be employed. A service may be contained within the limits of a designated trade route, as on Trade Route No. 31 (U. S. Gulf/West Coast South America) with its one service, or as on Trade Route No. 14 (U. S. Atlantic and Gulf/West Coast Africa) with its two services. On the other hand, a service may extend into another trade route as is the case on Trade Route No. 2 (U. S. Atlantic/West Coast South America) where the service provides not only for calls at ports on that route but also for calls at ports in Haiti and Colombia on Trade Route No. 4.

(1) subsidized service—this term signifies that service is being provided under an operating-differential subsidy contract for United States flag service on an essential U.S. foreign trade route.

(2) liner, berth, or regular service—these terms, often used interchangeably, to a service operating on a definite, advertised schedule, giving relatively frequent sailings at regular intervals between specific United States ports or range and designated foreign ports or range.

(3) non-liner, irregular, or tramp service —these terms have reference to operations of ships on an unscheduled basis as cargo offers, usually carrying full cargo lots, generally of a single bulk commodity, with no restricted trading limits.

short ton—2,000 lbs.

silting—the filling in of a harbor bottom by material that was suspended in a river flowing into or through the harbor.

spoil—the term applied to the material removed from land in making an excavation, or taken from under water by dredging.

tare weight—light weight of an empty container.

terminal—(1) the end of a movement in transportation; (2) the buildings, structures and equipment at the end of a transportation movement, for the transfer, handling, delivery and reception of passengers and freight.

through traffic—traffic moving through a waterway to and from points on other waterways.

tide—the rising and falling of large bodies of water produced by attractions of the sun and moon.

trade route—a specifically designated channel through which the commerce of the United States flows between a particular United States coastal area or areas and a specific foreign coastal area or areas.

trade route, essential—a route between ports in a United States coastal area or areas to foreign markets which has been determined by the Maritime Administration to be essential for the promotion, development, expansion, and maintenance of the foreign commerce of the United States.

transit shed—wharf structure for the short-time storage of merchandise in transit.

upbound and downbound—terms applied to movements within the confines of a river, intracoastal waterway, canal, or a segment of one of these channels.

vessel stowage factor—the number of cubic feet for stowing one weight ton (2,240 pounds of cargo on a specified vessel when fully loaded to its maximum permissible draft.

$$\frac{\text{(Bale Cubic)}\,450{,}000}{\text{(Cargo DWT)}\quad 6{,}000} = \begin{array}{c}\text{75 cubic feet per ton}\\ \text{(Cargo Stowage Factor)}\end{array}$$

warehouses—a structure in which goods may be stored at a minimum risk from fire, theft, fraud, or deterioration until further distribution. There are warehouses for transit storage, and merchandising warehouses.

weight ton—a weight ton is usually the long ton of 2,240 pounds but may also be the metric ton of 2,205 pounds or the short ton of 2,000 pounds depending upon the ships trade.

LIST OF ABBREVIATIONS

BOM—Bureau of Mines

CAB—Civil Aeronautics Board

COE—Corps of Engineers

DOT—Department of Transportation

DMA—Dominion Marine Association

dwt—deadweight tonnage

Fe—chemical symbol for iron

F.O.B.—Free on board; used in quoting prices of goods at the place of manufacture, not including transportation charges

GLBC—Great Lakes Basin Commission

GLBFS—Great Lakes Basin Framework Study

G.L.—Great Lakes

GNP—Gross National Product

ICC—Interstate Commerce Commission

iron Pl—iron and steel plates, shapes, and castings

LASH—lighter aboard ship

LCA—Lake Carriers Association

LELO—Lake Erie-Lake Ontario Waterway

Ls—chemical symbol for limestone

LWD—low water datum

MARAD—Maritime Administration

NA or N/A—not available or not applicable

OBERS—Office of Business Economics, Economic Research Service

Petro. Prod.—petroleum products

PSA—Planning Subarea

RBG—River Basin Group

Sand, gr.—sand, gravel, and crushed rock

SiO_2—silicone dioxide

SLSA—St. Lawrence Seaway Authority (Canadian)

SLSDC—St. Lawrence Seaway Development Corporation (U.S.)

SMSA—Standard Metropolitan Statistical Area

STOL—short take off and landing

U.S.S.R.—Union of Soviet Socialist Republics

VTOL—vertical take off and landing

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Annex

COSTS OF ENLARGED SYSTEM BY PLANNING SUBAREA

General

The estimated costs of enlarging the Great Lakes-St. Lawrence navigation system has been listed in Table C9–99 by planning subarea (PSA). The costs of dredging the interlake connections has been apportioned to the various channels based on a 1951 Corps of Engineers estimate. Basic cost data are taken from the Report of the Technical Subgroup, St. Lawrence Seaway Task Force, November 1968.[49] Costs would be considerably higher today and will be even greater in future years.

Estimate of Cost of Operation and Maintenance for Increased Capacity System

The Federal cost of operation and maintenance (O&M) on the Mississippi River in the St. Paul, Rock Island, and St. Louis Districts of the Corps of Engineers is used as a guide to the cost of operation and maintenance (Table C9–95). In a 33-year period the O&M costs have totaled from ⅔ to 1.0 of capital costs. Therefore, it is assumed that for new work, a 20-year time span will require a minimum expenditure for O&M of (20 years/30 years) times ⅔ = 4/9 or approximately ½ of the capital costs. Ten- and five-year periods will require ¼ to ⅛ of capital costs. Actual O&M costs on the Great Lakes for 1965–1969 are shown in Table C9–96.

Construction costs are assumed to occur at the middle year of each planning period, i.e., 1975 for the 1970–1980 period and 1990 for the 1980–2000 period. Therefore, operation and maintenance costs apply only to the second half of each period.

Estimated Cost of Enlarging System to 31, 32, and 34 Feet Depth

The cost of enlarging the system is presented in Tables C9–98 through C9–100 based on data in Report of the Technical Subgroup, St. Lawrence Seaway Task Force, November 1968.[49] The cost of extending the season for 31,

TABLE C9–95 Cost of Operation and Maintenance on Mississippi River, 1938 to 1971

District	Capital Cost	O&M
St. Paul	$90,000,000	$66,000,000
Rock Island	90,000,000	62,000,000
St. Louis	29,000,000	29,000,000

TABLE C9–96 Average Cost of Operation and Maintenance for Great Lakes-St. Lawrence Seaway System 1965 to 1969

	1965-1969 Average In $ Millions	
Item	United States	Canada
Connecting Channels	3.8	
Welland Canal		10.4
Seaway		
Canada		6.0
United States	2.0	
Harbors	3.4	NA
Total	9.2	16.4

TABLE C9–97 Distribution of Extension of Season Costs (6 weeks) (Millions of Dollars)

	Present System	Percent[a]	Depth (ft.) 31	32	34
Lake Superior	75	30	89	100	108
St. Marys River	7	3	8	9	11
Subtotal	82	33	97	109	119
Lake Michigan	37	15	44	49	54
Lake Huron	22	9	27	30	32
Detroit & St. Clair Rivers	14	6	17	19	22
Lake Erie	22	9	27	30	32
Welland Canal	7	3	10	11	11
Subtotal	102	42	125	139	151
Lake Ontario	27	11	33	37	40
St. Lawrence	35	14	40	44	49
Subtotal	62	25	73	81	89
Total	246	100	295	329	359

SOURCE: Reference 49, page 112.

[a]Percent of total cost for present system

32, and 34 foot deep systems is estimated in Table C9-97 based on estimated costs for the present 27-foot system. The cost of dredging interlake connections is apportioned in Table C9-98 based on a 1951 estimate by the Corps of Engineers. These costs are preliminary. An accurate estimate will not be available until the ongoing Great Lakes-St. Lawrence Seaway Navigation Season Extension Study is completed in 1978. Costs in Table C9-98 are for increasing the length of season at the same time as the system capacity is increased, and therefore differ from costs in Table C9-21 which represent lengthening the season after completion of improvements to increase system capacity. Costs have been grouped by planning periods for each planning subarea in Table C9-99 and C9-100 and by State in Table C9-101. Update costs of Lake Erie-Lake Ontario Waterway are shown in Table C9-102.

TABLE C9-98 Cost of Dredging Interlake Connections

	St. Marys River	Mackinac Straits	St. Clair River	Lake St. Clair	Detroit River	Total
Deepening to 35 Feet[a]						
Quantity (Million cu. yds)	115	2.2	41	20	37	
Unit Price	$ 1.44	$ 5.22	$ 0.96	$ 0.44	$ 3.69	
Total (Million $)	165	12	40	9	138	$364
Ratio[b]	0.450	0.35	0.110	0.025	0.380	1.000
31-Foot System						
Capital	277	20	68	15	235	615
Interest	40	3	10	2	37	92
Total (Million $)	317	23	78	17	272	707
32-Foot System						
Capital	331	24	82	18	280	735
Interest	51	4	11	3	42	111
Total (Million $)	382	28	93	21	322	846
34-Foot System						
Capital	590	43	145	33	499	1310
Interest	90	6	21	5	75	197
Total (Million $)	680	49	166	38	574	1507

SOURCE: Reference 49, pages 127 and 128

[a]1951 Corps estimate, Reference 49, page 125

[b]Total in millions of dollars divided by combined total (i.e., 165 ÷ 364 = 0.450)

TABLE C9-99 Feature Costs by Planning Subarea (United States only) 31-Foot System (Millions of Dollars)

	Dredging										
PSA	Harbors	Interlake Connections	LELO	Seaway and Iroquois Canal	Subtotal	Harbor Structures	Locks	Relocations[a]	Other Costs[a]	Extension of Season	Total
1.1	17.8	---	---	---	17.8	---	---	---	---	48.0	65.8
1.2	0.2	317.0	---	---	317.2	---	46.0[b]	---	---	49.0	412.2
2.1	---	---	---	---	---	---	---	---	---	7.0	7.0
2.2	95.9	---	---	---	95.9	36.4	---	---	---	22.0	154.3
2.3	---	---	---	---	---	---	---	---	---	8.0	8.0
2.4	0.6	23.0	---	---	23.6	---	---	---	---	7.6	31.2
3.1	---	---	---	---	---	---	---	---	---	27.0	27.0
3.2	---	---	---	---	---	---	---	---	---	---	0.0
4.1	11.4	367.0	---	---	378.4	4.6	57.0[c]	---	---	17.0	457.0
4.2	53.0	---	---	---	53.0	5.2	---	---	---	9.0	67.2
4.3	11.7	---	---	---	11.7	0.8	---	---	---	9.0	21.5
4.4	13.0	---	534.0	---	547.0	1.8	416.0[a]	214.0	152.0	19.0	1349.8
5.1	---	---	---	---	---	---	---	---	---	---	0.0
5.2	---	---	---	---	---	---	---	---	---	33.0	33.0
5.3	---	---	---	194.0	194.0	---	161.0[d]	---	---	40.0	395.0

[a]Lake Erie-Lake Ontario (LELO)

[b]Sault Ste. Marie (SOO Locks)

[c]St. Clair River

[d]Seaway

TABLE C9-100 Commercial Navigation Costs by Planning Subarea[a] (Millions of Dollars)

	Depth of System 31'	32'	34'	Depth of System 31'	32'	34'
1970-1980	Planning Subarea 1.1			Planning Subarea 1.2		
Extension of Season						
Capital	48	54	59	49	55	60
O & M	6	6	7	6	7	7
Total	54	60	66	55	62	67
1980-2000						
Great Lakes above Welland						
Sault Ste. Marie Locks						
Capital	--	--	--	46	48	51
O & M	--	--	--	11	11	11
Dredge Harbors[b]						
Capital	17.8	23.5	35.7	0.2	0.2	0.3
O & M	4	6	9	0.1	0.1	0.1
Dredge Channels						
Capital	--	--	--	317	382	680
O & M	--	--	--	80	95	170
Total Capital	17.8	23.5	35.7	363	430	731
Total O & M	4	6	9	91	106	181
Total O & M for 1970-1980 Construction	24	24	28	24	28	28
Total	45.8	53.5	72.7	478.0	564	840
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1970-2000 Construction	32	36	46	206	240	390
Total	32	36	46	206	240	390
1970-1980	Planning Subarea 2.1			Planning Subarea 2.2		
Extension of Season						
Capital	7.0	8.3	9.0	22.0	24.0	27.0
O & M	1.0	1.0	1.0	3.0	3.0	3.0
Total	8.0	9.3	10.0	25.0	27.0	30.0
1980-2000						
Great Lakes above Welland						
Dredge Harbors						
Capital	--	--	--	95.9	118.5	161.8
O & M	--	--	--	23.0	29.0	40.0
Harbor Structures	--	--	--	36.4	37.0	39.0
Total Capital	--	--	--	132.3	155.5	200.8
Total O & M	--	--	--	23.0	29.0	40.0
Total O & M for 1970-1980 Construction	4	4	4	12	12	12
Total	4	4	4	167.3	196.5	252.8
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1970-2000 Construction	4	4	4	58	70	92
Total	4	4	4	58	70	92

TABLE C9-100 (continued) Commercial Navigation Costs by Planning Subarea[a] (Millions of Dollars)

	Depth of System			Depth of System		
	31'	32'	34'	31'	32'	34'
1970-1980	Planning Subarea 2.3			Planning Subarea 2.4		
Extension of Season						
Capital	8.0	8.4	9.0	7.6	8.3	9.0
O & M	1.0	1.0	1.0	1.0	1.0	1.0
Total	9.0	9.4	10.0	8.6	9.3	10.0
1980-2000						
Great Lakes above Welland						
Dredge Harbors						
Capital	--	--	--	0.6	0.8	1.2
O & M	--	--	--	0.2	0.2	0.3
Dredge Channels						
Capital	--	--	--	23.0	28.0	49.0
O & M	--	--	--	6	7	12
Total Capital	--	--	--	23.6	28.8	50.2
Total O & M	--	--	--	6.2	7.2	12.3
Total O & M for 1970-1980 Construction	4	4	4	4	4	4
Total	4	4	4	33.8	40.0	66.5
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1980-2000 Construction	4	4	4	16.4	18.4	28.6
Total	4	4	4	16.4	18.4	28.6
1970-1980	Planning Subarea 3.1			Planning Subarea 4.1		
Extension of Season						
Capital	27.0	30.0	32.0	17	19	22
O & M	3	4	4	2	2	3
Total	30	34	36	19	21	25
1980-2000						
Great Lakes above Welland						
Locks (St. Clair River)						
Capital	--	--	--	57	60	62
O & M	--	--	--	12	13	13
Dredge Harbors						
Capital	--	--	--	11.4	14	19
O & M	--	--	--	3	4	5
Dredge Channels (St. Clair & Detroit Rivers)						
Capital	--	--	--	367	436	778
O & M	--	--	--	92	109	194
Harbor Structures	--	--	--	4.6	4.9	5.3
Total Capital	--	--	--	440	515	864
Total O & M	--	--	--	107	126	212
Total O & M for 1970-1980 Construction	12	16	16	8	8	12
Total	12	16	16	555	649	1,088
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1970-2000 Construction	12	16	16	222	260	436
Total	12	16	16	222	260	436

TABLE C9-100 (continued) Commercial Navigation Costs by Planning Subarea[a] (Millions of Dollars)

	Depth of System			Depth of System		
	31'	32'	34'	31'	32'	34'
1970-1980	Planning Subarea 4.2			Planning Subarea 4.3		
Extension of Season						
Capital	9	10	11	9	10	10
O & M	1	1	1	1	1	1
Total	10	11	12	10	11	11
1980-2000						
Dredge Harbors						
Capital	53[c]	66[c]	92[c]	11.7[d]	14.8[d]	21.9[d]
O & M	13	16	23	3	4	5
Harbor Structures	5.2	7.9	8.5	0.8	0.9	1.0
Total Capital	58	74	100	12.5	15.7	22.9
Total O & M	13	16	23	3	4	5
Total O & M for 1970-1980 Construction	4	4	4	4	4	4
Total	75	94	127	19.5	23.7	31.9
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1970-2000 Construction	30	36	50	10	12	14
Total	30	36	50	10	12	14

	Depth of System			Depth of System		
	31'	32'	34'	31'	32'	34'
1970-1980	Planning Subarea 4.4			Planning Subarea 5.2		
Extension of Season						
Capital	19	21	22	33	37	40
O & M	2	3	3	4	4	5
Total	21	24	25	37	41	45
1980-2000						
Locks						
Capital	416[d]	482[d]	530[d]	--	--	--
O & M	104[d]	121[d]	142[d]	--	--	--
Dredge Harbors						
Capital	13.0	15.2	24.0	--	--	--
O & M	3	4	6	--	--	--
Breakwaters						
Capital	92[d]	92[d]	92[d]	--	--	--
O & M	23[d]	23[d]	23[d]	--	--	--
Dredge Channels						
Capital	534[d]	579[d]	607[d]	--	--	--
O & M	134[d]	145[d]	152[d]	--	--	--
Relocations	214[d]	231[d]	231[d]	--	--	--
Other LELO Costs	152	160	167	--	--	--
Harbor Structures	1.8	1.9	2.0	--	--	--
Total Capital	1,423	1,561	1,663	--	--	--
Total O & M	264	293	325	--	--	--
Total O & M for 1970-1980 Construction	8	12	12	16	16	20
Total	1,695	1,866	2,000	16	16	20
2000-2020						
Capital	--	--	--	--	--	--
O & M for 1970-2000 Construction	536	598	662	16	16	20
Total	536	598	662	16	16	20

TABLE C9-100 (continued) Commercial Navigation Costs by Planning Subarea[a] (Millions of Dollars)

	Depth of System		
	31'	32'	34'
	Planning Subarea 5.3		
1970-1980			
Extension of Season			
Capital	40	44	49
O & M (1975-1980)	5	5	6
Total	45	49	55
1980-2000			
Dredging Costs[e]			
Unites States			
Capital[f]	125	150	269
Interest .06 x 2-1/2 = 0.15	19	22	40
Canada			
Capital	277	326	547
Interest	41	49	82
Locks[g]			
United States			
Capital	140	146	152
Interest	21	22	23
Canada			
Capital	246	257	271
Interest	37	39	41
Total Capital			
United States	305	340	484
Canada	601	671	941
Total O & M[h]			
United States	38	42	60
Canada	75	84	118
Combined Total			
United States	343	382	544
Canada	676	755	1,059
O & M for 1970-1980 Construction	20	20	24
Total	1,039	1,157	1,627
2000-2020			
Capital	--	--	--
O & M (United States only)	96	104	144
Total	96	104	144

[a]Includes interest during construction, 6% for half of 5-year construction period (i.e., capital costs + 15%).

[b]Does not include $112, $129, and $162 million for Thunder Bay in Canada in Planning Subarea 1.1.

[c]Great Lakes above Welland

[d]Lake Erie-Lake Ontario (LELO)

[e]Reference 49, page 127.

[f]Half of costs for 1,000 island section + all of cost for international rapids section. Reference 49, page 127.

[g]Reference 49, page 135.

[h]Assuming construction completed in 1995, i.e., O & M required for 5 years only (1995-2000).

TABLE C9-101 Cost of 31-Foot System by State

State	Item	Location	Cost (millions)
Minnesota	Harbor dredging	Silver Bay	0.2
		Taconite	0.6
		Duluth	17.0
		Subtotal	17.8
Wisconsin	Harbor dredging	Milwaukee	25.1
	Rebuild port structures to accommodate dredging	Milwaukee	33.6
		Subtotal	58.7
Illinois	Harbor dredging	Calumet	53.0
		Chicago	0.6
	Rebuild port structures to accommodate dredging	Calumet	2.5
		Chicago	0.3
		Subtotal	56.4
Indiana	Harbor dredging	Indiana Harbor	11.2
		Port of Indiana	6.0
		Subtotal	17.2
Michigan	Harbor dredging	Marquette	0.2
		Escanaba	0.6
		Detroit	11.4
	Rebuild port structures to accommodate dredging	Detroit	4.6
			16.8
	Dredging connecting channels	St. Marys River	317.0
		Straits of Mackinac	23.0
		St. Clair River	78.0
		Lake St. Clair	17.0
		Detroit River	272.0
			707.0
	New lock	Sault Ste. Marie	46.0
	Lock and Dam	St. Clair River	57.0
			103.0
		Subtotal	826.8
Ohio	Harbor dredging	Toledo	38.0
		Sandusky	15.0
		Lorain	5.3
		Cleveland	6.0
		Conneaut	0.4
			64.7
	Rebuild port structures to accommodate dredging	Toledo	5.2
		Conneaut	0.8
			6.0
		Subtotal	70.7
Pennsylvania	Not Estimated		
New York	Harbor dredging	Buffalo	13.0
	Rebuild port structures to accommodate dredging	Buffalo	1.8
			14.8
	All-American Canal		1,408.0
		Subtotal	1,422.8
International	St. Lawrence Seaway Dredging	United States	
		1/2 of Thousand Islands	16.6
		Entire International Section	127.6
			144.2
		Canada	
		1/2 of Thousand Islands	16.6
		Lake St. Francis, Lachine & Soulanges	251.0
		Iroquois Canal	50.0
			317.6
		Total Seaway Dredging	461.8
	Locks	United States	161.0
		Canada	283.0
			444.0
		Total Seaway Dredging and Locks	905.8
Canada (other costs)	Harbor dredging	Thunder Bay	112.0
		Hamilton	0.2
		Toronto	5.7
	Rebuild port structures to accommodate dredging	Hamilton	2.8
		Toronto	6.0
		Subtotal	126.7
Total United States Costs			2,775.6
Total Canadian Costs			727.3
Grand Total			$3,502.9

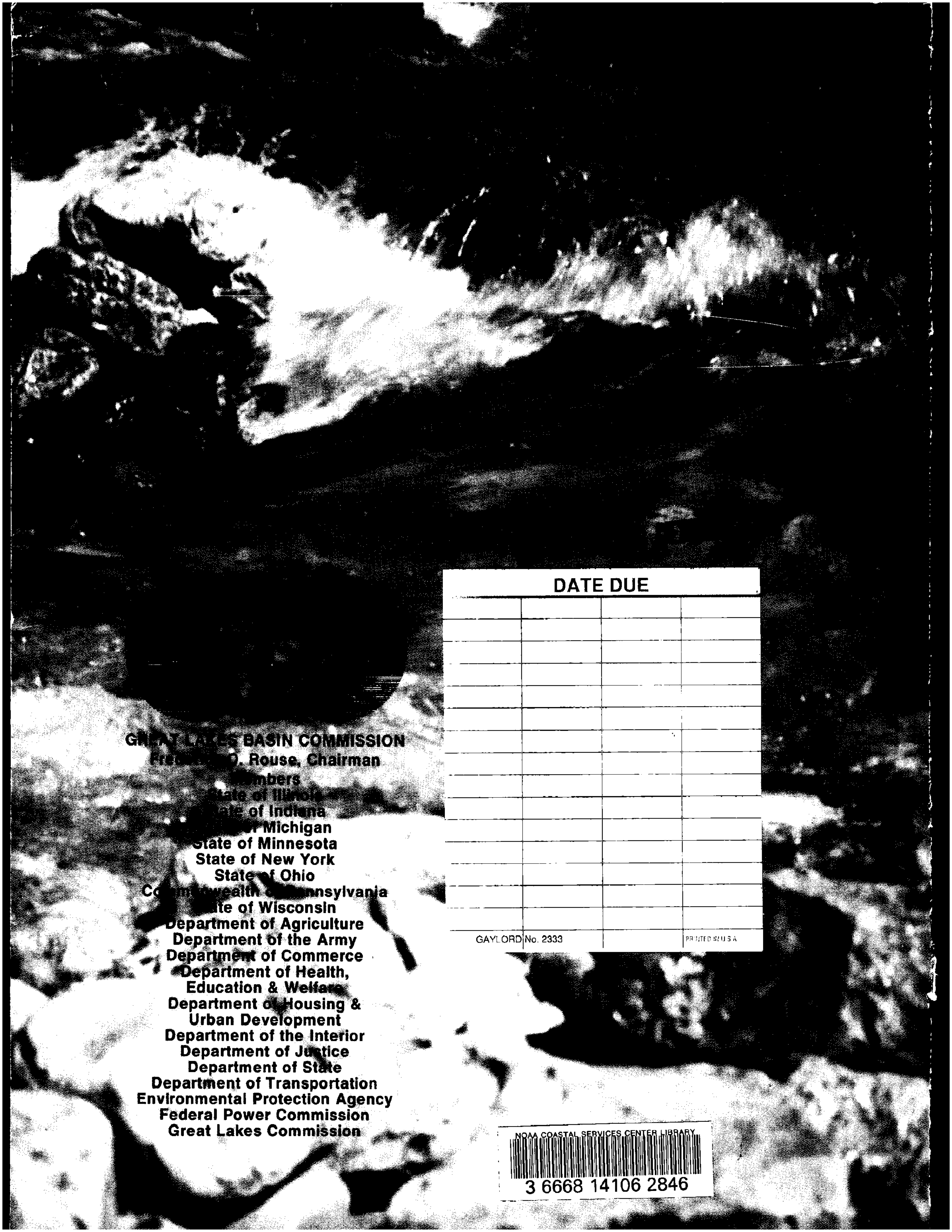
SOURCE: Report of the Technical Subgroup; St. Lawrence Seaway Task Force, Department of Transportation, November 1968. Estimate for Port of Indiana added.

TABLE C9–102 Update Cost of Lake Erie-Lake Ontario Waterway[a] (Millions of Dollars)

Item	1961[b] Est.	Update to 1968[b] (140%)	31' System Capital	31' System Interest	31' System Total	32' System Capital	32' System Interest	32' System Total	34' System Capital	34' System Interest	34' System Total
Relocation	112	156	186	28	214	201	30	231	201	30	231
Locks	216	302	362	54	416	419	63	482	461	69	530
Channels	321	450	464	70	534	504	75	579	528	79	607
Breakwater	57	80	80	12	92	80	12	92	80	12	92
Other Costs	84	118	132	20	152	139	21	160	145	22	167
	790	1,106	1,224	184	1,408	1,342	201	1,544	1,414	212	1,626

[a]Reference 49, pages 138-146.

[b]Evaluated for a 27' system.



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